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AN EXTENSION OF THE OLD HYATT PATENT covering the use of a coagulant in mechanical filtration is being sought at the hands of Congress. The patent will expire in February, unless Congress can be induced to extend it. Cincinnati and other cities proposing to establish mechanical filters on a large scale are opposing the extension.

THE $12,000,000 NEW ORLEANS BOND ISSUE for acquiring and extending water-works, for establishing a system of sanitary sewers and for completing the drainage system has been sold at 104.619. The bonds bear 4% interest.

WATER PURIFICATION EXPERIMENTS at Springfield, Mass., are to be made at the joint expense of the city water department and the State Board of Health, the latter furnishing a chemist, as we understand it. One of the chief objects of the experiments is to determine whether it is practicable to prevent or remove the tastes and odors from the Ludlow storage reservoir, which have continued so persistently for a long time. The plant includes two circular tanks, about 17 × 15 ft., and two filters, each having an area of 1-200th acre, besides the necessary piping and accessories. The filters are covered with earth, resting on plank. The experimental plant has been developed by Mr. Percy M. Blake, of Hyde Park, Mass., in accordance with suggestions from the State Board of Health.

INVESTIGATIONS FOR A NEW WATER SUPPLY for Greater New York are contemplated by Mr. Wm. Dalton, Commissioner of Water Supply, who has requested the Board of Estimate to authorize $100,000 of bonds for the purpose. The request was referred to Mr. Bird S. Coler, Comptroller of the city.

THE OFFICES OF THE METROPOLITAN WATER Board, of Boston, Mass., have been removed to No. 1 Ashburton Place, a point near the State House and not far from the old location on Mt. Vernon St. The cause of the change, it is a pleasure to report, is the proposed removal of the row of old dwelling houses on Mt. Vernon St., to add to the open space surrounding the State House. A number of other state and metropolitan commissions have been housed in these offices for some years past, including the State Topographical Survey and the Metropolitan Sewerage Commission.

A SIPHON OF LEAD PIPE, without an air chamber or pump, was put in use at Schooner Head, Bar Harbor, Me., on April 9, 1900, and had been in constant use without recharging and without waste of water up to Oct. 17, 1900. The pipe is 1 in. in diameter and has wiped lead joints. It replaced a 2-in. galvanized pipe, with screw joints, which had given much trouble on account of breaks in the siphon action, it being possible to maintain a constant flow only by wasting water at the lower end. The pipe line supplies a few private houses and a golf club. The supply is taken from a small pond, about 400 ft. above sea level and some 350 ft. above the houses and grounds in question. Near the pond is a ridge about 200 ft. wide, rising about 12 ft. above the pond, composed of hard rock. It was estimated that trenching through the rock would cost several thousand dollars, but the lead pipe cost some $250. A portion of the old 2-in. iron pipe is used as a vent to get rid of any air carried over from the pond. Since the new pipe was laid the level of the pond has been lowered but little by the draft on it, instead of seriously, on account of the old waste pipe, and the pressure at the houses has been increased, the loss of head due to substituting 1-in. lead for 2-in. iron pipe being more than offset by the saving in friction due to the constant discharge of the waste pipe. Of course it will be generally understood that the substitution of a few lead wiped joints for the many leaky joints of the galvanized iron pipe constitutes its claim to superiority. Attempts to make the joints of the iron pipe air tight after the pipe was laid proved unsuccessful. For the above facts we are indebted to a paper by Mr. Robt. S. Hale, read before the Boston Society of Civil Engineers and published in the Journal of the Association of Engineering Societies for November, 1900.

THE FIRE LOSS FOR 1900, in the United States and Canada, aggregated $163,362,250. This is a large increase over the previous two years, when this loss was $136,773,200 and $119,650,500 respectively. In the last year the Ottawa-Hull fire loss was $12,000,000, and the loss by the burning of the Hoboken docks, steamers, etc., was $5,350,000. In the year 2,400 fires caused a loss exceeding $10,000 each.

THE WATER PURIFICATION STATION at New Orleans, La., was put in operation during the past month, with Mr. Robert S. Weston in direct charge. At this station studies will be made to aid in determining the best means of purifying the water of the Mississippi River, in accordance with the plans now being prepared for the sewerage and water board under the direction of Mr. Geo. G. Earl, M. Am. Soc. C. E., General Superintendent, and the advisory board of engineers, which board is composed of Messrs. B. M. Harrod, Rudolph Hering, Geo. W. Fuller, L. W. Brown and A. C. Bell.

RELINING THE MILLBURN STORAGE RESERVOIR of the Brooklyn water-works at a cost not to exceed $500,000 is proposed in a resolution which has been passed by the Board of Public Improvements of New York city. The work must be authorized by the municipal assembly. The reservoir was built a number of years ago, but will not hold water. It is said that concrete will be used for the new lining.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred at Lorman, Miss., on the Yazoo & Mississippi Valley Ry. on Jan. 2. Two freight trains collided in a deep cut on a curve, wrecking the locomotives and killing five men. The accident is believed to have been due to an imperfect understanding of orders by one of the enginemen.

SEPTIC TANKS, AERATING WEIRS AND DOUBLE contact filter beds for Plainfield, N. J., have been recommended by Jos. O. Osgood, Consulting Engineer. The council committee on streets and sewers, in its annual report, dated Dec. 27, 1900, endorses the plan and recommends that it "be adopted by the common council early in 1901, and that proposals be invited for constructing the works." The plans and specifications have been approved by the State Board of Sewerage Commissioners. The scheme includes two tanks, each about 50 × 100 ft., with 6 ft. of depth below the surface of the sewage, covered with a wood, tar and gravel roof. This would give a combined capacity of about 450,000 gallons, not allowing for deposits of sludge, which is equivalent to about the present daily flow of sewage. There would be eight 92 × 106 ft. contact beds, with concrete walls and floors, filled with 4 ft of
stone or other hard material in sizes up to 1 in. in diameter, in which the bacterial work is to be done, with a cover of another foot of similar coarse material.
The beds would work in two sets of four each, being on different levels. The sewage would flow by gravity from the outlet sewer into and through the tanks and the successive beds. Mr. Osgood states that in preparing the plans, specifications and estimates for the proposed improvements he has been assisted by Mr. A. J. Gavett, City Surveyor of Plainfield, "who is entitled to credit for many valuable suggestions as well as for the final drawing of the plans." The proposed new works are designed to supersede the intermittent filtration area put in operation in the early part of 1896 and described in Engineering News of Sept. 10, 1896. The filter beds have given much trouble through clogging, which appears to have been due to a combination of causes, including heavier dosing and different operation in other respects than was contemplated in the original plans.

THE INCOME AND EXPENDITURES of railways in the United States for the year ending June 30, 1900, are summarized in an advance report recently made public by the Statistician of the Interstate Commerce Commission. According to this summary the gross earnings of the railways included in this report were $1,480,673,054, or $7,776 per mile of line. Of these earnings $396,860,760 were classed as passenger earnings, and $1,048,268,875 as freight earnings. The gross earnings shown in the final report for the preceding year were $1,313,610,118. Operating expenses for the last fiscal year aggregated $956,814,142, or $5,025 per mile of line. The net earnings of the roads embraced in this advance report were $523,858,912 for 1900, or $73,110,747 more than they were in 1899. Income from investments and other sources, amounting to $60,675,700, were received, so that the total income was $584,534,612. The total deductions from income were $395,811,056. This item includes interest on bonds, rents for leased lines, taxes ($44,936,165), and other charges to income. The amount of dividends declared was $109,400,147, which is $27,555,388 greater than the amount declared by corresponding roads in 1899. The resulting surplus form the operation of the roads covered by this preliminary report was $79,323,409. The surplus shown in the final report for the preceding year was $53,064,877. The report states that it should be understood that the amount of dividends stated does not include the dividends paid to stockholders by railway companies the mileage of which is operated under lease or some other form of control.

PENNSYLVANIA RAILWAYS, says the last annual report of the Pennsylvania Bureau of Railways, aggregate in length 10,576 miles within the state out of 25,885 miles operated within and outside the state. These Pennsylvania steam railway companies, of which there are 443 corporations, owned 11,747 locomotives, 10,709 passenger cars, 512,048 freight cars, and employed 307,737 men, and paid these men $176,762,468. The passenger earnings amounted to $109,757,426; the freight earnings, $331,013,955, and with miscellaneous items added the gross income was nearly $500,000,000. Deducting $428,837,899 gross expenditures, the dividends payable were $37,823,386. The total invested capital was $2,965,077,932. The Pennsylvania Railway alone employed 60,161 men and paid them $36,937,356 in wages, an average of about $616 per year per man. The bureau report, in all, deals with 977 corporations, from which reports were received. Of these 443 were steam railways, 400 were street or passenger railways, 130 were telegraph or telephone companies, and 4 were canal companies.

RUSSIAN RAILWAYS, on Aug. 1, 1900, says the London "Economist," aggregated 32,640 miles. The railways of normal gage on Dec. 31, 1899, aggregated 26,929 miles in length, and operated 8,452 locomotives and 243,674 cars. The total freight traffic on these last roads in 1899 amounted to 64,346,000 long tons, an increase of about 20% over the business of 1897. Grain, coal, petroleum and timber formed the bulk of this traffic. The average haul was 287 miles per ton in 1899, and the gross earnings per English mile was £1,673, as against £1,917 in 1897. This decrease is explained by the less satisfactory working of newly opened lines. Of the total length of Russian railways on Aug. 1, 1900, and open for traffic 27,900 English miles were in European Russia, 3,360 miles in Siberia and 1,380 miles in Central Asia. The cost of building 15,376 miles of state railway in Europeon Russia was £252,659,860; that of 2,846 miles in Siberia and Central Asia, was £24,369,015. The total traffic expenses in 1898 amounted to £20,621,949; the interest paid on bonds was £16,770,889, and the net profit on shares was £2,163,984. As the expenses of construction and the traffic account are given for 27,846 and 26,972 miles respectively, the net profit of working can only be approximated. This amounted to 4.3% in 1898 on the capital spent; the Siberian and Asian road showed a deficit of £831,109 in the same year.

AN UNDERGROUND SUBURBAN TERMINAL is proposed by the New York Central & Hudson River R. R., at the Grand Central Station in New York city. According to the published reports the suburban tracks will pass underground at about 57th St. and make a loop under the yards and station, returning to the surface again at 57th St. The end of the loop will reach to near the 42d St. front of the present station and will connect by platforms with the 42d St. line of the Rapid Transit Subway. Connection with the street surface will be secured by elevators and stairways. The effect of the new underground loop will, therefore, be to separate the station tracks for the suburban trains from those for the through trains, which will remain at the present level. It will also make possible through trains from down town New York to the suburban towns of the New York Central, New York & Harlem, and New York, New Haven & Hartford railways.

REPAIRS OF LOCOMOTIVE FIRE BOXES are best effected by "box" or "raised" patches, according to a recent paper read before the Western Ry. Club by Mr. W. H. Graves foreman of the Burlington & Missouri River R. R. shops at Edgemont, South Dakota. Such a patch consists of a sheet of steel dished up two or three inches from a flanged base, the flanges being secured to the firebox by patch bolts. In making such patches, Mr. Graves advises well-rounded corners and a narrow lap to the flange beyond the patch bolt, and suggested that standard sizes could be made with dies and kept in stock at local repair shops.

COMPETITIVE DESIGNS FOR THE 95TH ST. BASCULE BRIDGE OVER THE CALUMET RIVER, CHICAGO.

The necessity of improving the navigation of the Chicago and Calumet rivers has led the city of Chicago to adopt the policy of replacing all center-pier drawbridges with bascule bridges, so that a large number of bridges of this type are likely to be built for that city within the next few years. In May, 1900, the Commissioner of Public Works invited competitive designs and proposals for the construction of a bascule bridge over the Calumet River at 95th St. to replace an old structure which had collapsed (Eng. News, Aug. 24, 1899). Three designs were prepared by the engineers of the city, and five designs were submitted by outside bidders, some of these bidders having two or more alternate designs differing in matters of detail. All the designs were for bridges revolving on fixed trunnion bearings, with one exception. In the latter case the curved heel was to rest and turn upon roller bearings, no actual trunnion or shaft being used. The competition, like most of its class, was not very satisfactory, partly for the reason that the plans were to include both substructure and superstructure, thus making it almost impossible to compare the designs on any uniform basis. The award was made to one of the designs prepared by the city, which had been submitted to a board of consulting engineers, as noted below.

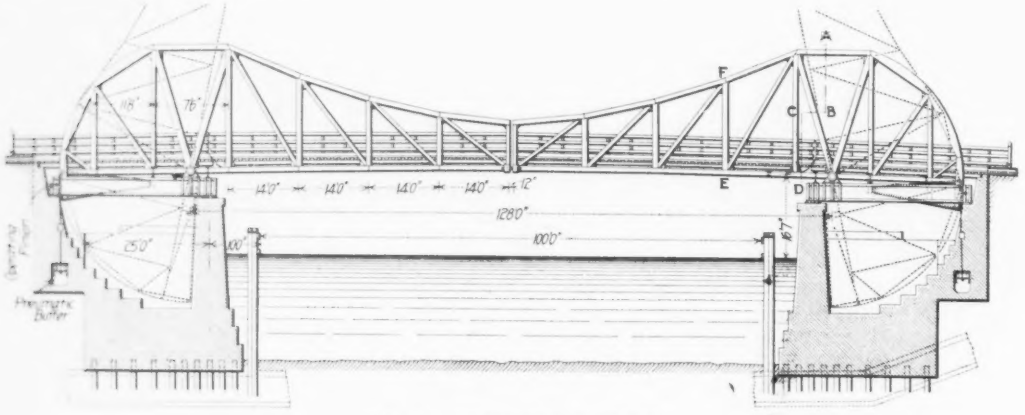


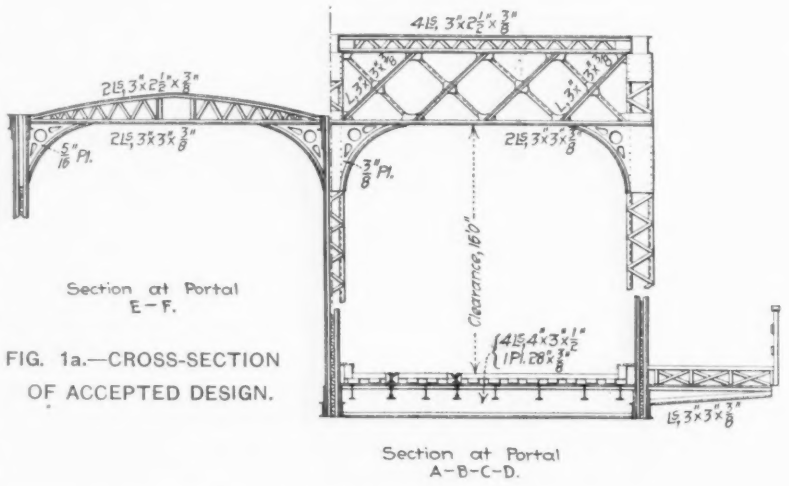
FIG. 1.—ACCEPTED DESIGN.

John Ericson, City Engineer.
Edward Wilmann, City Bridge Engineer.
Roemheld & Gallery, General Contractors.
American Bridge Co., Contractors for Superstructure.

ACCEPTED DESIGN.

The accepted design, shown in Fig. 1, is for a double-leaf structure, with three through trusses, 128 ft. c. to c. of trunnion bearings, giving a clear waterway of 100 ft. between the timber protection works. The back arms of the trusses are 26 ft. long, and each carries a heavy cast-iron counterweight. These arms carry no flooring, but simply move in slots or openings provided in the fixed flooring of the approach. The trusses are 9 ft. deep at the meeting ends (c. to c. of chords) and 24 ft. over the piers, where they are connected by portal bracing, giving a clearance of 16 ft. above the floor. When the bridge is open, this bracing comes down to about 8 ft. above the level of the roadway. The three trusses are spaced 21 ft. c. to c., and have cantilever brackets for outside sidewalks. The floor beams are plate girders, with eight lines of stringers to each roadway; two of these stringers are plate girders and carry the rails of the electric railway, the others are steel I-beams. The center of gravity of each leaf is between the center line of the outer pier and the trunnions, which are set back 4 ft. from this center line. The trunnions are supported on plate girders, which also carry the fixed approach over the chambers for the counterweighted heels of the trusses. The total weight of each leaf is about 300 tons.

On the curved heel of each truss is a cast-steel rack, with teeth 6 ins. pitch and 9½ ins. wide. Openings between the teeth prevent the packing of dirt or ice. Engaging with the rack is a 23-in. pinion, driven through a train of gearing by two 38-HP. electric motors on each side of the bridge. When the bridge is closed, the two leaves are connected by longitudinal bolt locks working in sockets in the bottom chords. The bolts are actuated by levers from the operating house. No lock is needed to hold the leaves when open, as in this position the center of gravity is moved to a position behind the center of rotation, so that the leaves tend to remain upright until force is applied to lower them. To check the motion of the bridge as it reaches the end of its travel in either direction, pneumatic buffers are used.



Section at Portal E–F.

FIG. 1a.—CROSS-SECTION OF ACCEPTED DESIGN.

Section at Portal A–B–C–D.

The masonry at each end, as originally designed and shown in the drawing, consisted of a pier of Portland cement concrete resting on a pile foundation, and having three pockets for the counterweighted heels of the trusses between the front and rear piers. The details of this have been modified, and one large pocket substituted.

This design (with two others differing in detail) was prepared under the direction of Mr. John Ericson, City Engineer, and Mr. Edward Wilmann, City Bridge Engineer. When bids were invited for the construction of the 95th St. bridge, a bid and design based on these plans was submitted by Roemheld & Gallery, 91 Dearborn St., Chicago, and the contract was let to them at $151,800. They have commenced work on the substructure, and the contract for the superstructure has been sublet to the American Bridge Co., of New York.

The three designs above-mentioned were submitted by Mr. L. E. McGann, Commissioner of Public Works, to a board of engineers composed of Messrs. E. L. Cooley, Ralph Modjeski and Byron B. Carter. They approved the design which was afterwards accepted, but recommended certain modifications. The following is an abstract of their report:

The principle of the trunnion bearing meets with our approval as a very simple solution of the problem, the chief advantages being the constant point and direction of application of the load on the foundation, whether the bridge is in motion or stationary, and the reduction of the number of moving parts to the minimum. The first advantage is of no great consequence if the piers are placed on an unyielding foundation, but with such foundations as can be obtained in Chicago at the majority of bridge sites, it is of great importance. The trunnion type of bridge used in these designs is an old and tried device, and is not covered by patents.

The bascule design permits of placing the center of gravity of the moving bridge in the trunnion axis or its proximity. The placing of the center of gravity a short distance from the axis of the trunnions towards the draw opening and the arrangement, as designed, by which the fixed floor relieves the tail end from any possible live load, have this advantage, that they tend to hold the bascule firmly in position when closed without absolute necessity for heel locks. There is no tilting effect due to the action of live load coming onto the bridge.

At the site of the bridge the bed rock is from 55.5 to 58.5 ft. below Chicago datum. It would, therefore, be impracticable, from the point of view of expense, to place the masonry on rock. It is almost certain, in our opinion, that piles cannot be driven to that depth; but they can be driven into the hard clay overlying the bed rock, and this seems to be the most practical method of foundation for this particular bridge. In case of more important structures, however, where the magnitude of the work would warrant the additional expense, we would strongly recommend that the foundations be carried to bed rock by pneumatic or other process, so as to obtain an unyielding foundation.

We do not consider the design of the piers as entirely satisfactory. The number of pits and partitions and the irregularities in the concrete have a tendency to start cracks and fissures, while owing to the large co-efficient of expansion of concrete, it is desirable to make the body of the pier of as simple a form as possible. Our proposed modification consists in making one counterweight pit by dispensing with partitions. The bottom of this pit is formed by an inverted concrete-steel arch 3-ft. thick, with 10-in. I-beams placed near the upper surface. The footing of the abutment is placed at the same elevation as the pier and founded on piles. The inverted arch ties the abutment to the pier, and, as it is an established fact that concrete-steel beams are elastic, this inverted arch will accommodate itself, without cracking, to slight unequal settlements.

This inverted arch also transmits a part of the earth pressure of the retaining wall to the foundation of the river pier. This, however, should not be considered in determining the sizes of the piers and abutments, but may be regarded as an additional advantage. We find it desirable to imbed a frame of steel in the body of the pier. This frame consists of three posts—one under each bearing—and two horizontal members—one near the coping and one near the base—acting as top and bottom chords. In this manner the pier will be made one single mass, and the alinement of the three trunnions will remain true even if settlements should occur. In this modified design, the supporting girders would be firmly anchored at both ends, without any provision for expansion. As the coefficients of expansion for concrete and steel are practically the same, the end walls of the counterweight pit will expand together with the girders, causing a slight deflection in the river pier. The imbedded cross-frame in this pier, how-

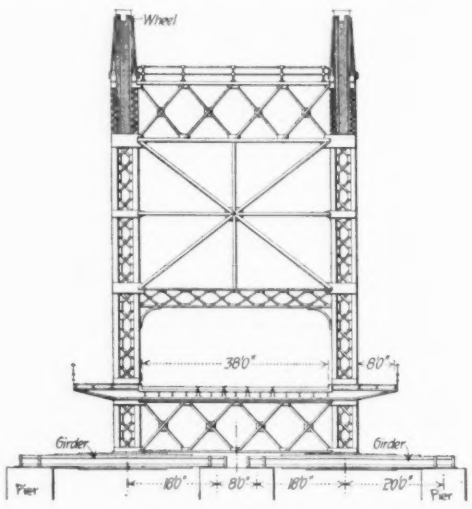


Fig. 3a.—Cross Section of Milwaukee Bridge & Ironworks' Design.

ever, will permit its deflecting without detriment to the concrete. To reduce the risk of water seeping through the concrete into the counterweight pits, we recommend that the concrete about the pits be faced with Portland cement mortar. This mortar to be built in at the same time with the concrete so as to bond or blend with it. The cost of the piers as modified will not exceed that of the piers as originally designed.

The three-truss design, as prepared by the city, is preferable to a two-truss design for the same width of floor, and therefore we recommend its adoption. The curved pawls or heel locks may be necessary in connection with the resting blocks. They should be capable of lifting the tail ends and holding them firmly against the anchorage. This arrangement would also facilitate the overhauling and adjustment of the trunnion bearings.

Air buffers, as contemplated, are practical, but should have more travel in action than as designed. The pistons should not withdraw from the cylinders, and should be packed with cupped leather or other packing, thus preventing entrance of foreign matter or grit into the cylinders. Air may be controlled in the cylinders by allowing free entrance through check-valves, and exit through adjustable openings, for buffing. Springs may be provided to insure proper action of the pistons. Those providing for open draw should be carried upon the supporting girders, entirely independent of the main pinion bearing.

merits. If made with large pitch and large angle of worm and running in an oil bath, the friction of the gears running light may not be large, but, by the ingenious application of a light rope belt (to revolve the worm), the friction due to the thrust of the worm is practically eliminated until the brake is applied. In the detail design, the desirability of friction brakes applied directly to the curved segments of the trusses may be developed.

It is fair to state that the assumed wind loads against opening or closing the bridge may never prevail in the practical handling of the bridge, and may be regarded as so much additional security. The fact is that ships do not navigate when such winds prevail, and there would be no occasion to open the draw at such times. In the case of the Tower Bridge (London), the reserve power put in on account of extra wind loads was reported as "never used" at the end of two years.

In general, our board is of the opinion that the flow of the river should be provided for in the opening of the draw wherever practicable.

We desire to conclude by stating that the designs submitted to us disclosed very careful and able study on the part of those in charge.

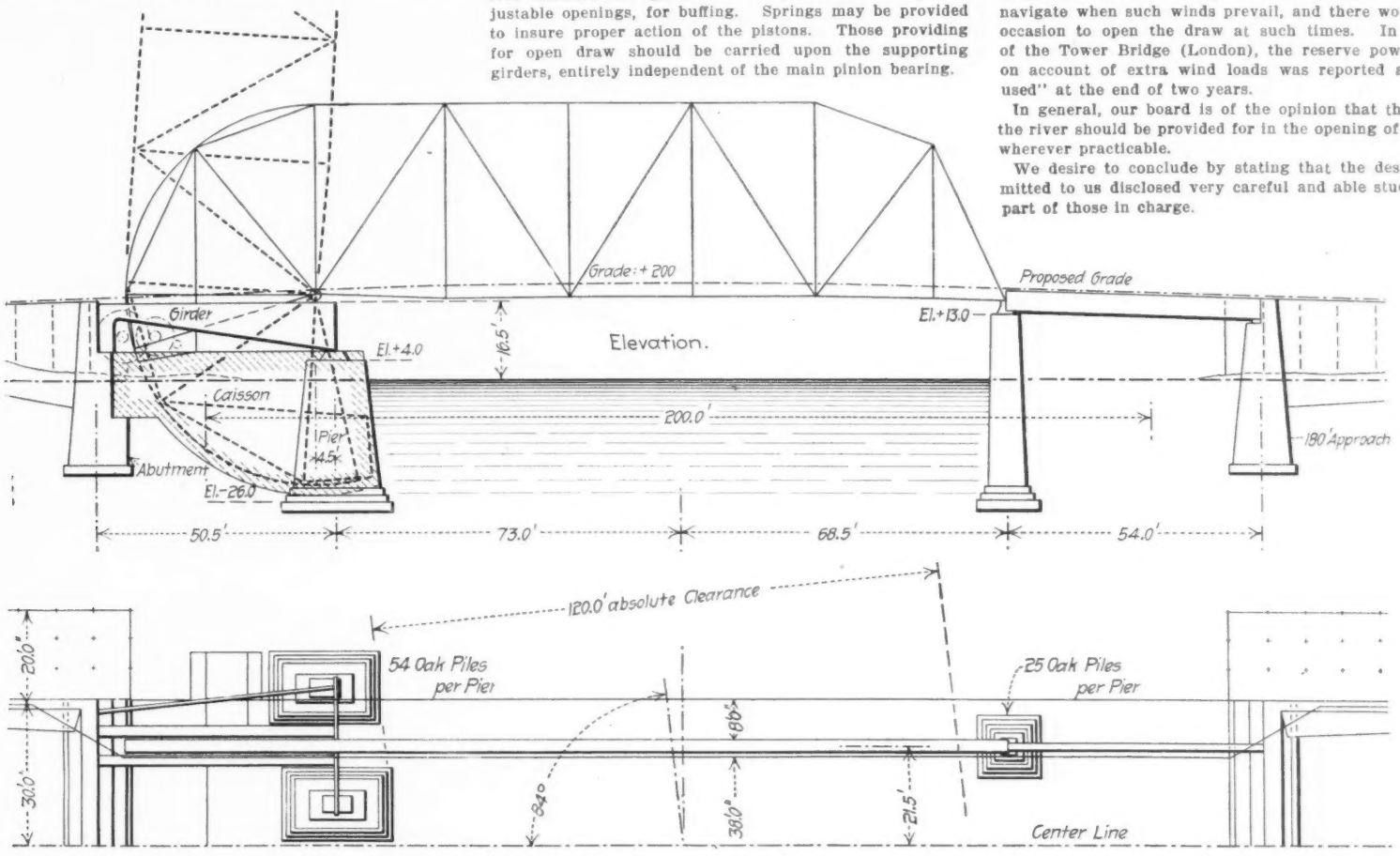


FIG. 2.—DESIGN OF THE CHICAGO BRIDGE & IRON WORKS.

bottom lateral struts should be omitted and a stiff lateral system used. The floor-beams can be supported, when the bridge is raised, by angles running from the middle of each floor-beam to the intersection of the lateral angles. We would also advise that the heel ends of the trusses be connected by a transverse brace, to add lateral stiffness to the racks and the counterweights. Provision should be made to prevent people or animals from being caught by the members of the trusses while the bridge is in operation.

We recommend that adjustable resting blocks be placed in front of, and near the trunnions so that when the draw closes, the load may be transferred from the trunnions to the resting blocks. This will facilitate the lubrication and will practically eliminate the starting friction of the trunnions. To meet all possible conditions of wind and incidental changes in the position of the center of gravity,

The very strong racks on the heel of the draw with through openings between the rack cogs, meet with our approval as they will not accumulate ice in cold weather. On those rare occasions when sleet may coat the racks with ice, the shaft and pinions are strong enough to force the ice through the cog openings. Moreover, in the ice season there is little navigation in the river, and therefore little occasion to open the draw.

We find that there is no practical difficulty in making the driving machinery strong enough to resist all probable strains which it may be required to carry, and recommend the following general arrangement: The three pinions mounted on one line of shafting, with specially strong bearings, being driven by two gears; these two gears connected by a jack shaft and suitable pinions, with two gears mounted, and clutch-driven, on this jack shaft. The jack shaft gears driven by two independent gearing trains to two motors. All these gears, shafts and motors arranged in a vertical or inclined train, so proportioned that all gears are between their respective shaft bearings. The bearings to have ample length and all mounted, as far as possible, on one structure. The gearing may easily be made stronger and safer and more accessible for overhauling and repairs than that of any existing city bridge.

Besides the usual band-brake on the motor shaft, the proposed worm-gear brake for emergency use has novel

DESIGN OF THE CHICAGO BRIDGE & IRON CO., CHICAGO, ILL.

This design, shown in Fig. 2, was for a single-leaf bascule span, 146 ft. long from center of bearings, with two through trusses. These trusses are 40 ft. deep, and have back arms 40 ft. long. The piers are 141 ft. 6 ins. c. to c., giving a clear waterway of 120 ft. A plate girder span of 50 ft. 6 ins. carries the approach roadway, the back arms of the trusses acting simply as counterweights and part of the operating machinery. Four pedestal piers support the trunnion bearings. One of the most striking features of the design is the provision of movable pockets to re-

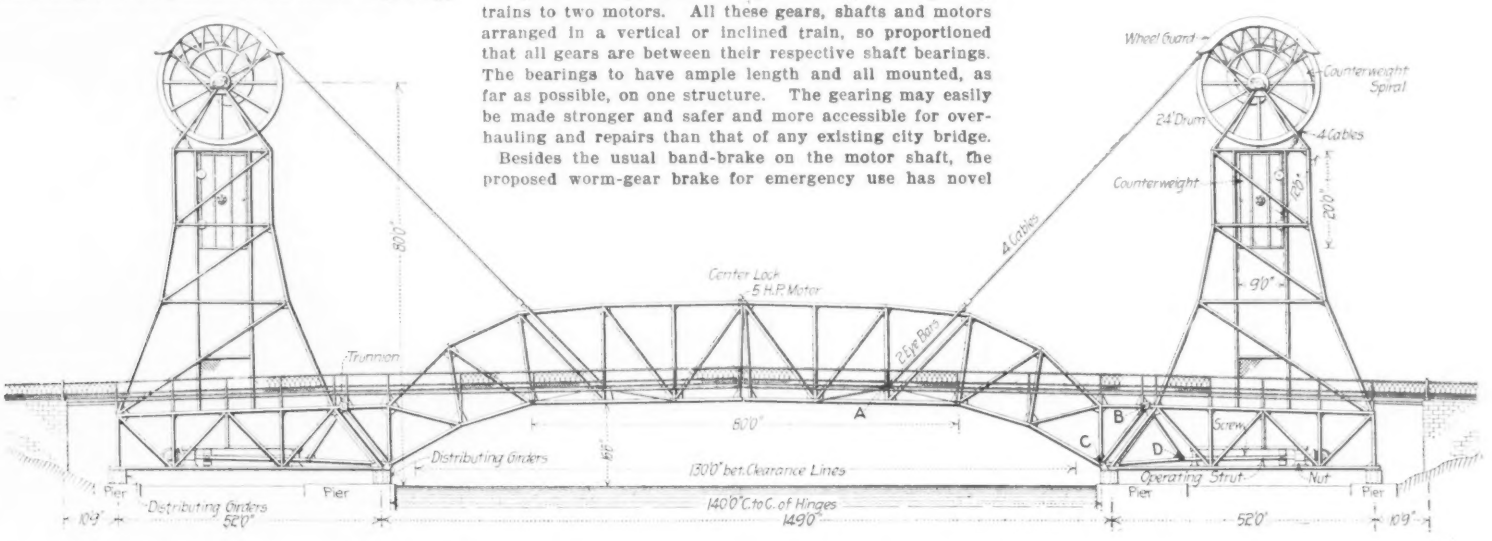


FIG. 3.—DESIGN OF THE MILWAUKEE BRIDGE & IRON WORKS.

ceive the heels of the trusses. The projection of the counterweights under the trusses would be in advance of the trunnions when the bridge is open, and this, with the necessary thicknesses of a masonry pocket, would encroach upon the waterway. The plan, therefore, provides for steel

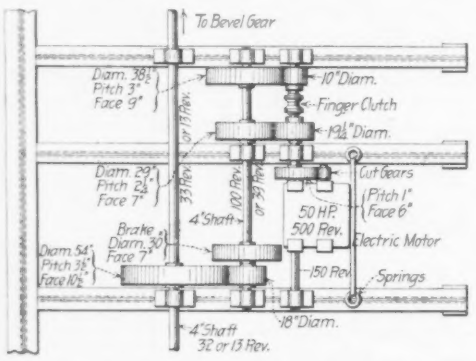


Fig. 3b.—Diagram Plan Showing Operating Machinery of the Milwaukee Bridge & Ironworks' Design.

caissons fitted between the pedestal piers and the abutments, and capable of being removed for repairs. This is shown by the heavy line, A, B, C, D, E. A plate-girder approach span of 54 ft. from the rest pier to the abutment provides additional waterway. The two trusses are 43 ft. c. to c., with a 38-ft. roadway between them, and two 8-ft. sidewalks on the outside. The total weight of the moving part of the structure was estimated at 1,050 tons, which was fully counterbalanced, leaving only the inertia to be overcome in starting the bridge. The center of gravity coincided with the center of rotation. The span is supported by trunnions 30 ins. diameter (with an 8-in. hole in each), having a bearing area of 876 sq. ins. On the curved heel of each truss is a cast-steel rack, gearing with a pinion placed under the approach span. The operating machinery is driven by four 80-HP. electric motors coupled in pairs, each pair having a band brake with solenoid attachment, while the main gear wheel has also a brake wheel cast with it. Only two of the motors would be required under normal conditions. The bridge is counterbalanced to stop in any position when the power is shut off, while electrical attachments provide for bringing it to rest without shock at either end of the travel. No locks or latches are required, and the reaction from live load is as direct as in a fixed bridge. The amount of the bid was $150,000.

In a statement acompanying this design, the following interesting particulars were given as to the operation of a structure of such weight, 1,050 tons:

> The only comparison we can present as to operating a mass as large, is the Ferris Wheel, which weighed 1,400 tons, and operated on two journals 31 ins. diameter and 60 ins. long, or in round numbers, 600 lbs. per sq. in. bearing on the journals. It is our understanding that there was not a particle of difficulty as to the lubricating of these journals, which covers the entire question as to resistance or wear of parts. The Ferris Wheel is 250 ft. diameter. It presented very much larger exposure to wind than the bridge can, and it was operated at as high a rate of speed as is contemplated in the operation of the bridge.
>
> The power required to operate the Ferris Wheel under normal conditions was about 50-HP. at the engine, which stands in the same relation to the wheel as the motors will to the bridge. Indicator cards were taken from the engine while operating at the time of one of the heaviest wind storms of recent years, and the resistance ran up only to approximately 90 HP. These facts may be readily verified, and the writer believes they form the only information at hand as to operating a mass of 1,000 tons on journal bearings. It may not be out of place to suggest, that the problem is one of machinery rather than of the bridge, and machinery of the most ponderous proportions. In our design we have proposed four electric motors, aggregating 320 HP. This becomes a necessity under the specifications to operate against 25 lbs. wind pressure at a given rate of speed. While this we believe to be three times as much power as there will ever be required, it has one very desirable advantage in the strength of the working parts, and this is exactly where surplus strength is undoubtedly wanted as a safety measure. Controllers will be furnished to cause the motors to start in series, and later to work in parallel. Also, mechanical arrangements will be provided so the motors may work in pairs of two, the other two being idle as a relay.

DESIGN OF MILWAUKEE BRIDGE & IRON WORKS, MILWAUKEE, WIS.

This design, shown in Fig. 3, differs from all the others in having counterweights sliding vertically in steel-framed towers and connected to the trusses by steel wire cables. The bridge has two leaves, each with two half-through trusses, with pivot bearings just under the roadway (over the piers), and hinge pin bearings on the edges of the piers. These latter bearings are 140 ft. c. to c., when the bridge is closed, and the distance between clearance lines of the pile protection work is 130 ft. Both chords are curved downward at the heel, the top chord passing below the level of the roadway. The bridge carries a single 38-ft. roadway and two 8-ft. sidewalks outside the trusses. At each end of the bridge is a steel tower, the legs resting on distributing girders supported by pedestal piers. This arrangement was adopted in order to avoid gas and water tunnels under the river, but it has objectionable features, and added considerably to the estimated cost of the structure. The lower part of the tower carries the approach. On the top of each tower are two bull-wheels, each grooved to carry eight 1⅜-in. wire ropes. These wheels are 24 ft. diameter, and on each side of the rim are grooves for two of the four cables running to the trusses. Between these is a spiral drum for the four counterweight cables, the radius of this drum decreasing from 12 ft. to 3 ft., so as to give a rapid initial movement to the bridge, the speed reducing as the bridge reaches the end of its travel. This arrangement requires less weight than if the cables were vertical. The height from the water line to the axles of the bull-wheels is 80 ft. The four cables to each truss are attached to U-bolts, taking hold of a pin just above the truss, from which a pair of eye-bars extends to an 8-in. pin (A) in one of the truss posts. From smaller side-pins looped bars and eyebars are run to the nearest panel points of the bottom chord, as shown. The counterweights have rollers running on vertical guides.

The operating machinery consists of an operating strut attached to the heel of the truss and driven by a screw and nut. The truss revolves on the trunnion bearing (B), and has a hinge pin at (C), while the operating strut is connected to the pin (D) at the extreme point of the heel. Under each side of each tower is a steel screw 8 ins. diameter, and about 16 ft. long, slightly inclined from the horizontal. This is driven by bevel gearing and a train of spur gearing by means of a 50-HP. electric motor at each end of the bridge. On the screw travels a nut which has rollers bearing against top and bottom guides, and side pins for two operating struts running to the pin (D) of the truss. The bridge is shown closed, with the nut at the shore end of the screw. To operate the bridge, the screw is revolved and the nut travels outward, the pin (C) moving outward and upward in a circle, of which the trunnion bearing is the center. The center lock is a bolt fitted to the top chord and moving laterally, the end of the chord of one leaf being recessed to receive the end of the chord on the other leaf. A 5-HP. motor on the end of the latter leaf drives a shaft having two pinions which (when the bridge is closed) gear with spur wheels in the other leaf. The hubs of the spur wheels are mounted on nuts operating the threaded bolt locks. The total weight of each leaf is 120 tons, fully counterbalanced.

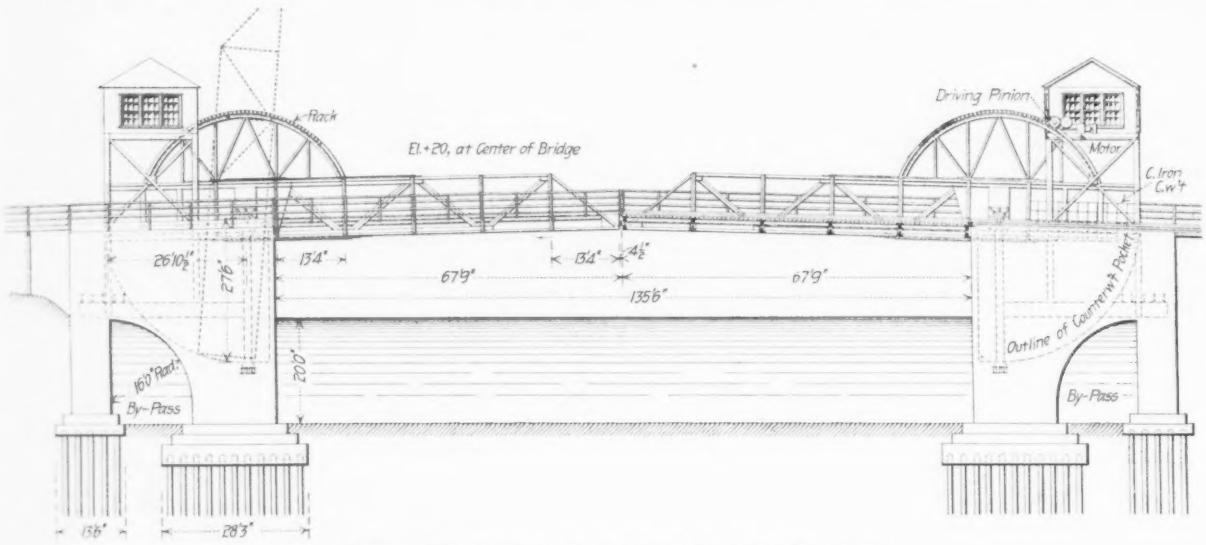


FIG. 4.—DESIGN OF J. W. SCHAUB, M. AM. SOC. C. E.

DESIGN OF J. W. SCHAUB, M. AM. SOC. C. E., CHICAGO, ILL.

This design, Fig. 4, is for a double-leaf structure, with a clear span of 135 ft. 6 ins. between the faces of the abutments, or 120 ft. between the rows of protection piling. The trunnions are 19 ins. in diameter, and the bearings are anchored directly to the abutments, in which are formed the pockets or pits for the counterweighted heels of the trusses, while a by-pass is also provided through the masonry of each abutment, as shown. Two designs were submitted, for two and three trusses respectively. The trusses are 11 ft. deep, and each one has a circular arc of 20 ft. 6 ins. radius, to which the operating rack is attached. As the trusses are comparatively shallow, these curved members rise considerably above them. The counterweights are cast-iron blocks packed against the webs of the plate-girder heels of the trusses. The total weight of each leaf for the three-truss or double roadway design is 435 tons. In regard to the operating machinery, the most striking feature is the use of overhead gearing, mounted in towers or cabins supported by steel bents and trusses spanning the roadway. The rack is composed of 3-in. cold-drawn steel pins, with a pitch of 9 27-64 ins., inserted between the chord plates on the curved members. A 24-in. pinion engages with each rack, and is driven by interlocking worm wheels with Hindley gear

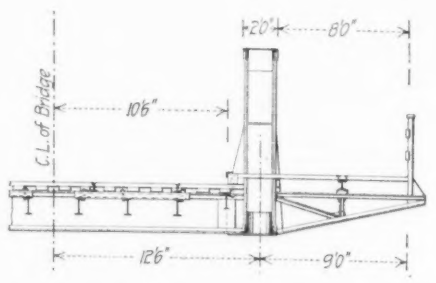


Fig. 4a.—Half Cross Section, J. W. Schaub's Design, for Single Roadway.

by means of electric motors. For the single roadway design there are two motors of 40 HP. each at each end of the bridge, or one 50-HP. motor at each end for the single roadway design. Bolt locks or latches pass through the center floor beams when the bridge is closed.

It was suggested that the operating towers might be arranged within masonry arched portals or entrances designed for architectural effect, but although much has been said about the desirability of some artistic and architectural treatment of the Chicago River structures, the city has no

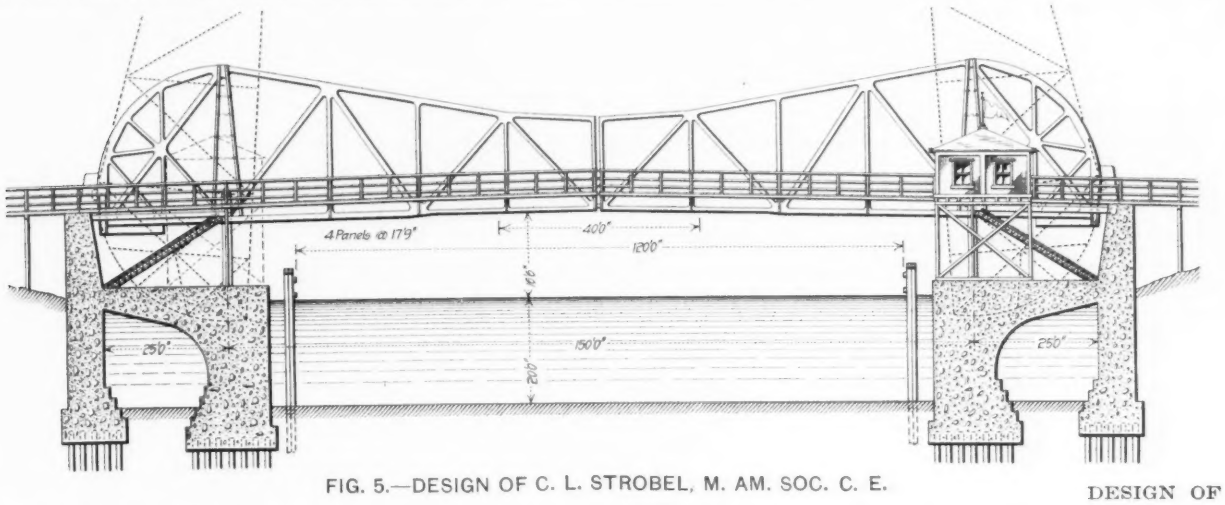


FIG. 5.—DESIGN OF C. L. STROBEL, M. AM. SOC. C. E.

funds available for such a purpose at this time. Mr. Schaub's designs were submitted by Mr. C. L. Strobel, together with his own designs noted below, the prices of the bids for the superstructure being $86,000, and $59,000 for the double and single roadway designs, respectively.

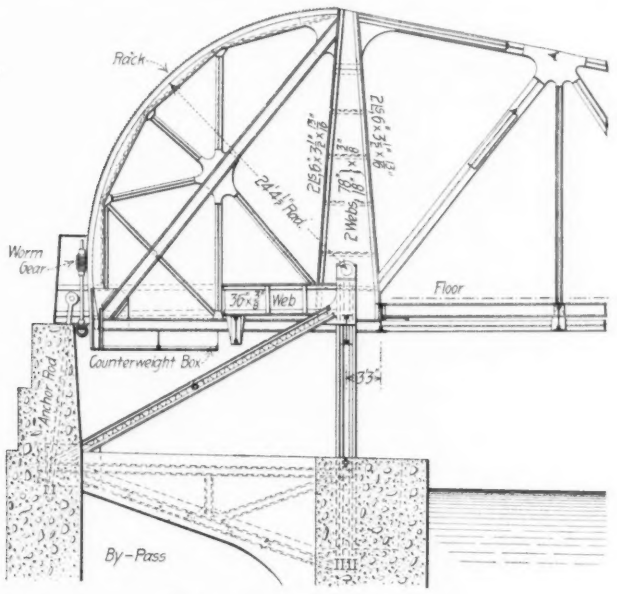
DESIGN OF C. L. STROBEL, M. AM. SOC. C. E., CHICAGO, ILL.

This design, Fig. 5, is for a double-leaf bascule bridge, with trunnion bearings 150 ft. c. to c., and tail arms 25 ft. long. The clear waterway normal to the direction of the river is 120 ft. between the protection piling. Three trusses, 29 ft. high over the piers, and 19 ft. high in the center of span, are placed 22 ft. c. to c., thus providing for two roadways of 18 ft. clearance between the wheelguards. Two sidewalks of 8 ft. clearance are carried by cantilever brackets outside the trusses. At the tail arm enough counterweight is provided to make the center of gravity of the movable part coincide with the center of the trunnions for any position of the leaves. The break in the floor is made 3 ft. 3 ins. from the trunnions (towards the river), so that when the bridge is opened the movable floor forms a barrier for the stationary floor. The trunnions are hollow cast-steel shafts, 15 ins. diameter, rigidly keyed into the girder posts of the trusses, and are supported at each side of the trusses by cast-steel pillow blocks bolted to the top of heavy steel columns on the piers. These columns rest on I-beam bolsters, imbedded in the river piers 8 ft. below city datum. The two columns supporting each truss are spread apart at the bottom to allow the counterweight to swing between them in a concrete pocket. The pier columns also support the stationary floor, and stiff bracing is provided crossways between the pairs of columns, as shown. The concrete pockets (one for each tail arm) are 6 ft. wide in the clear and span the space between the river piers and the abutments, thus providing for a by-pass underneath them. Steel trussing is imbedded in the side walls of the counterweight pockets, and connected at one end to the pier columns and at the other end to the longitudinal diagonal struts which connect the top of the pier columns with the abutments. In this way the abutments and piers are very substantially connected.

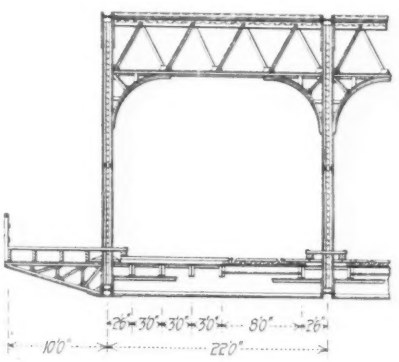
The tail portion of each truss is made circular, with the trunnions as the center, and contains the operating rack, whose radius is about 24 ft. At the tail ends an anchorage arrangement with bumpers is provided. Several designs for operation were submitted. In one of them, the operating rack is formed by steel pins 3⅝ ins. diameter, 9 ins. c. to c., fitted between the web plates of the circular tail portion and held in position by cotter pins. These rack pins can very easily be replaced, when necessary. Another advantage of this arrangement is, that no dirt or sand can collect between the pins. This pin rack is engaged by a steel pinion of 23 ins. diameter and 9 ins. face, the necessary train of gears being placed between the motor and the main pinion. For another design submitted, a circular cast-steel rack with cut teeth of 2½ ins. pitch and 11 ins. face is securely fastened to the circular tail portion of each truss. This is engaged by a double-threaded bronze worm of 5 ins. pitch, whose axis is sufficiently inclined to cause the threads of the worm to mesh properly with the teeth of the rack. Bevel gear and shafting transmit the motion from the motor to the worm. A dust-protector for the rack consists of a flexible steel band, which forms the cover of a box, and is always drawn tightly against the rack by a steel spring. The worm is oiled by an endless belt with felt blocks fastened to it. The lower end of this belt is immersed in oil, and the felt blocks after being saturated with oil engage with the threads of the worm, thus oiling it. All these details were clearly shown in the drawings submitted. The rack is proportioned so that any one of the seven teeth in contact will sustain the maximum pressure under ordinary conditions. The worms have a slight possible motion vertically on their shafts, so that when the bridge is closed, no pressure is exerted upon the gearing. A band brake for controlling the motion is also provided. The time for opening or closing the bridge was figured as 1 minute, of which 15 seconds were allowed for the operation of the locks. Two 40-HP. motors are provided for each side of the bridge. The bids for the superstructure, varying with the different arrangements of operating machinery, ranged from $72,000 to $80,000.

DESIGN OF WADDELL & HEDRICK, KANSAS CITY, MO.

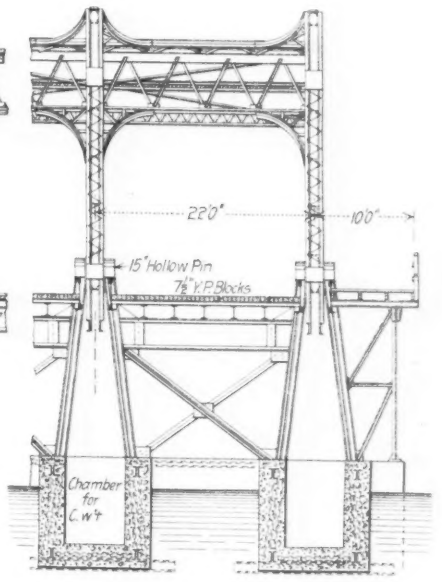
This design, Fig. 6, provided for two leaves, each carried by a pair of plate girders, forming when closed a through span of 156 ft. c. to c. of piers, with a clear waterway of 120 ft. The girders have segmental heels of 13 ft. radius, each resting upon a pair of anti-friction rollers on the piers, so that no trunnion bearings are required. The girders are 40 ft. c. to c., and have plate-girder floor beams and cantilever brackets for the sidewalks. Within the curved chord of each heel is a steel rack, gearing with two pinions, the operating machinery being driven by four 40-HP. motors (two at each end of the bridge). The center of gravity coincides with the center of rotation. The dead load of the girders is 3,400 lbs. per lin. ft. of span; live load for floor, a 17-ton steam roller or 100 lbs. per sq. ft. of roadway and sidewalks; wind load, 350 lbs. per lin. ft. of span for lateral system, or 24 lbs. per sq. ft. of exposed area when operating. The time for opening is taken as 1 minute under ordinary conditions, or 2½ minutes under 24 lbs. wind pressure. The weight of each leaf is 420 tons, including counterweights, and the total weight is counterbalanced. The heel carries the floor and has a heavy concrete counterweight. When the bridge is closed, the heels take a bearing under the ends of the approach girders, and a cast-steel latch (moving laterally) engages with an opening



Part Longitudinal Section.



Half Cross Section of Bridge.



Half Cross Section of Approach.

FIG. 5a.—LONGITUDINAL AND CROSS-SECTIONS OF C. L. STROBEL'S DESIGN.

formed by slots in the ends of the girders. The masonry consists of two piers and an abutment at each end, with no connecting masonry. This design was submitted by the Lydon & Drews Co., of Chicago, with a bid of $112,700.

DESIGN OF WM. L. BRAYTON.

In connection with the competitive designs above described, we illustrate in Fig. 7 a form of bascule bridge designed and patented by Mr. Wm. L. Brayton, of Harrisburg, Pa. Although designed for the 95th St. crossing of the Calumet River, it was decided not to submit the design in competition, but it was presented by its inventor as a thesis for the degree of civil engineer at the Kansas State University.

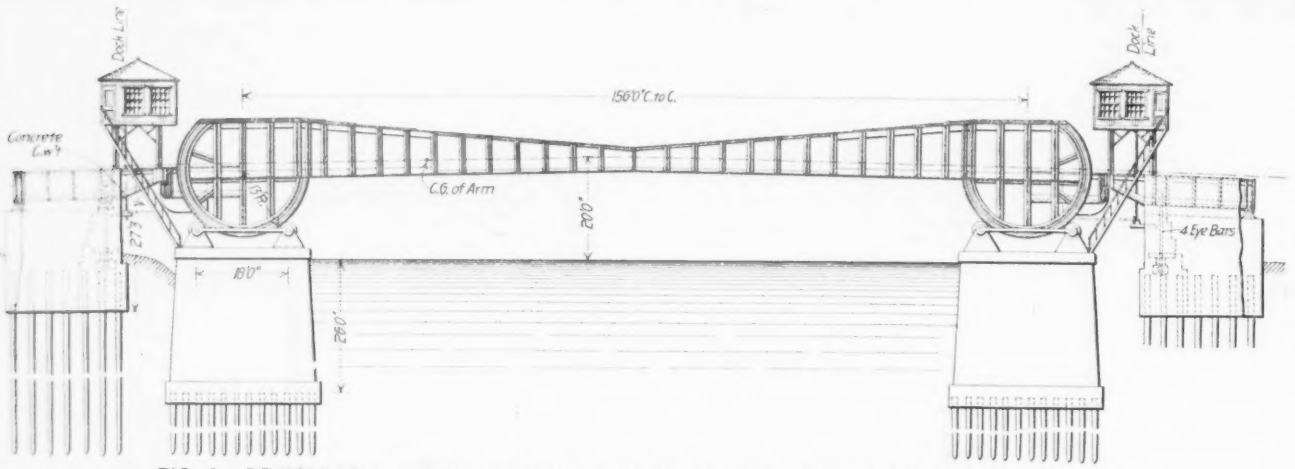


FIG. 6.—DESIGN OF WADDELL & HEDRICK (SUBMITTED BY THE LYDON & DREWS CO.)

As will be seen from the drawings, the bridge consists of two bascule arms hinged by means of horizontal transverse axles on the tops of steel framework towers resting on masonry abutments. The inshore ends of the bascule arms carry a counterweight and a segmental rack; pinions gearing with the racks and operated through trains of gearing by motors located in power houses out on the abutment masonry on each side supply the surplus power over the counterweights to raise the river arms and clear the channel. The river ends of the two bascule arms meet on a diagonal plane, as shown, and both the top and bottom chords are positively locked. The top chord locks consist of taper pins on one end entering taper holes on the other end, and the bottom chord locks are two hooks which mesh with each other as the bridge closes. The top chord pin locks are actuated positively by shafts and gearing operated from the power house.

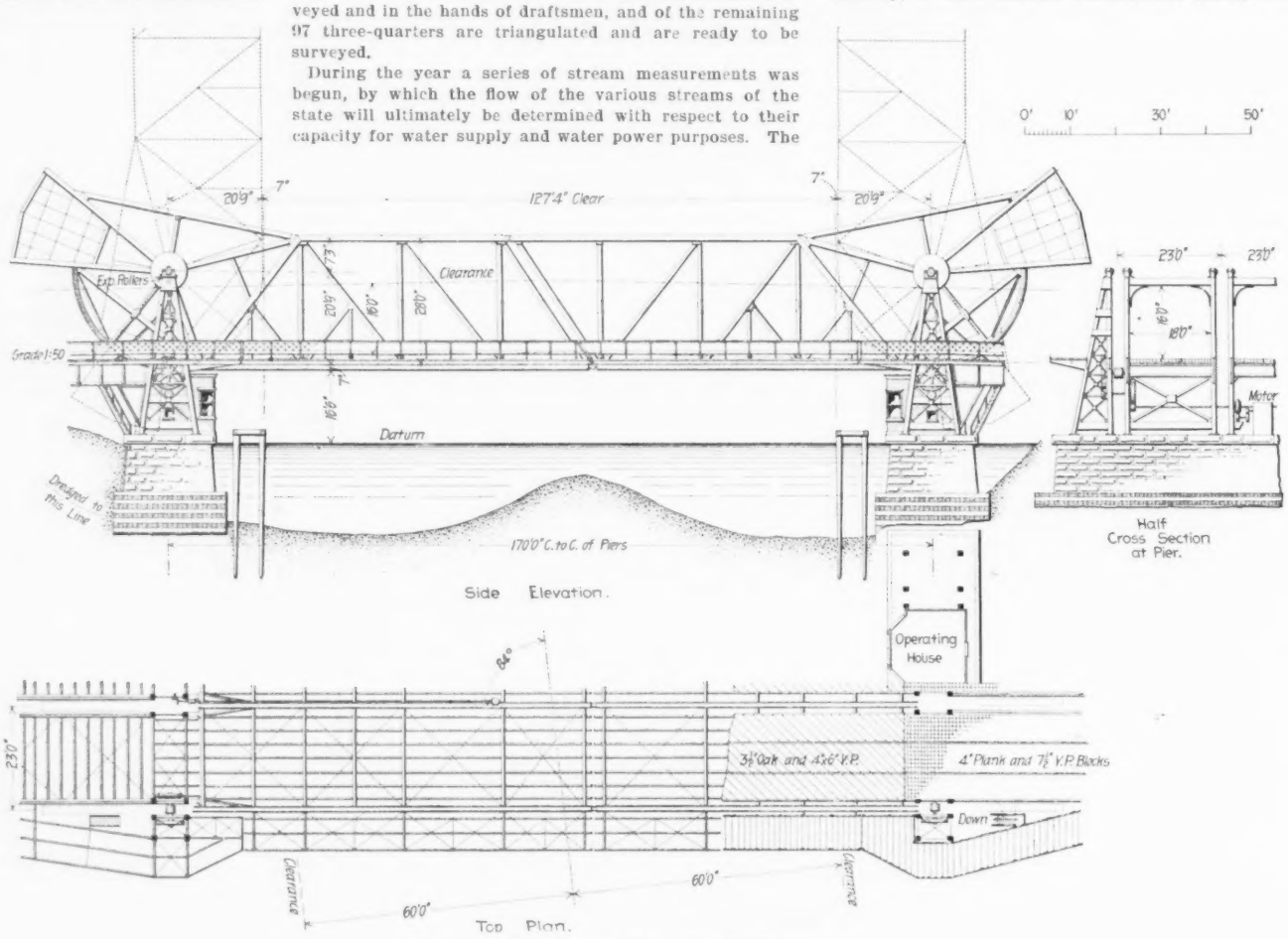


FIG. 7.—DESIGN OF WM. L. BRAYTON.

The especially meritorious features which the inventor claims for his design are: That by the use of high towers the necessity of wells in the abutment masonry to provide for the counterweights is entirely avoided, and that by locking the chords, all thrusts or overturning moments on the abutments are avoided, the piers being, therefore, designed for the vertical load only.

THE REPORT OF THE STATE ENGINEER OF NEW YORK.

A summary of the report of Mr. Edward A. Bond, State Engineer and Surveyor of New York, has been sent out from the office of that official at Albany, N. Y., from which we take the following items of general interest to engineers:

One of the principal duties of the State Engineer during the past year has been the making of a survey and plans and estimates for a barge canal across the state, for which work the Legislature appropriated $200,000 on April 12, 1900. This survey is completed and the results are in the progress of preparation and will be presented to the Legislature in a special report in February.

The topographical survey of the state has been in progress in co-operation with the United States. The results are published in sheets 12 ins. × 18 ins., showing about 12 miles × 18 miles, so that 240 sheets will cover the state. Of these 102 are completed and published, 15 sheets are mapped and in the hands of the engravers, 26 are surveyed and in the hands of draftsmen, and of the remaining 97 three-quarters are triangulated and are ready to be surveyed.

During the year a series of stream measurements was begun, by which the flow of the various streams of the state will ultimately be determined with respect to their capacity for water supply and water power purposes. The results of this work will be submitted to the Legislature in a separate report.

The State Engineer has also had charge of the survey, design and construction of good roads under the Higbie-Armstrong law of 1898, under which law the sum of $250,000 has been appropriated by the state during the three years it has been in force. In this way 23 roads have been built, located in twelve counties and aggregating 53½ miles. In addition to this 131 petitions have been received from 27 counties for an aggregate of 800 miles, of which surveys and estimates have been made or are in progress for 80 roads in 23 counties, aggregating 406 miles and showing an average estimated or actual cost of $7,625 per mile. Those roads which have been completed have given unqualified satisfaction to the people who have used them and have helped to pay for them, and in nearly every case the immediate result has been the presentation of petitions for the extension of the road so built.

During 1899 there was built in one county a gravel road, which has given entire satisfaction and which cost much less than a macadam road would have cost. There have since been many calls from different parts of the state for roads of this or a similar character, and it has been decided to recommend these cheaper roads where heavy traffic does not make it necessary to build the high-class and more costly macadam roads, and thus to enable those counties who have at yet made no petitions to avail themselves of the good roads law.

Improved roads are wanted by the people in all parts of the state, and the omission of 34 counties to take action under the Higbie-Armstrong law of 1898 has been because of the great cost of building the crushed stone macadam roads, which are usually meant when "Good Roads" are mentioned. Some counties can afford to pay one-half of the cost of the first-class, crushed rock roads which are built by state aid at $7,000 to $9,000 per mile, but many other counties equally want improved roads which are neither so good nor so costly as the macadam roads.

The provisions of the Higbie-Armstrong law are such that the State Engineer is enabled to select for the improvement of any highway a telford, macadam or gravel roadway, or other suitable construction, taking into consideration the climate, soil and materials to be had in that vicinity, and the extent and nature of the traffic likely to be upon the highway, specifying in his judgment the kind of road which a wise economy demands. Under this provision the surveys and estimates which have been made during 1899 and 1900 have in every case, where the conditions make it desirable, provided for the use of local stone or local gravel, but the State Engineer now decides to carry this action still further and to make merely im-

proved roads for such counties or towns as do not want macadam roads. This will be done in such way that little of the work will have been wasted, if it is later desired to form a good macadam road on the same highway.

The existing roadway will be properly cleared of sod and stone and properly graded with the ditches and culverts necessary for perfect drainage, and the natural material forming the present road will be properly formed and "crowned" and rolled, as is now done to form a subgrade for a macadam road. If the natural soil is light sand, as is often the case, this sand will be covered with 6 ins. of clay or shale, if such material is within reach, and the surface will then be rolled until it is hard and firm. If the natural soil is argillaceous sand or soft clay or loam which make deep mud when wet, such material will be covered with gravel if it can be found in the vicinity and can be used without too great cost. If the natural soil is a mixture of gravel and loam, as is frequently the case, this material itself will form a fair roadway when crowned and ditched and rolled.

In any such case an "improved" road will thus be made which will be vastly better than any former condition of such a highway and which will drain itself much quicker, and be in every way much better than the existing roadway. It will not be a macadam road, but it will be an "improved" road and its total cost will be less than one-third of the cost of a macadam road, or say, $2,000 or $3,000 per mile. If the local authorities should later desire to make a macadam road on such an improved highway, the grading and ditching and forming which have been described will be so much work already done towards forming such a high-grade macadam road. By this means it is hoped to enable many of the rural counties of the state to have the benefit of state aid for the improvement of their highways.

MUNICIPAL IMPROVEMENTS AT CHARLESTON, S. C.

The public works at Charleston, S. C., with the exception of sewers, are in charge of the street committee of the city council. All petitions for improvements are made to the city council, referred to this committee, then to the city engineer and finally executed under the direction of a superintendent of streets, subject to the inspection of the city engineer. Mr. J. B. Keckly is now superintendent of streets. There is a superintendent of the scavenger department, at present Mr. J. D. Jervey, who reports to the s reet superintendent.

Plans for all public works, except for sanitary sewers, are made by the city engineer. That official generally prepares estimates; on small jobs of repairing sometimes only quantities are figured, the superintendent of streets then filling in the prices. The total appropriation for the department of engineering in 1899, aside from the salary of the engineer and his principal assistant, but including all other assistants, was $1,250.

Mr. J. H. Dingle is city engineer, and Mr. D. C. Barbot is assistant city engineer. We are indebted to these gentlemen for courtesies extended to a member of the editorial staff of this journal, while in Charleston, last month, and also for much of the information on which this article is based.

Charleston is greatly hampered by its financial limitations. It inherited a large bonded indebtedness, on account of railway construction before the war, and its debt is in excess of the legal limit. It cannot levy assessments for benefits, that practice being unconstitutional in South Carolina. All improvements, therefore, must be paid for from the proceeds of general taxation.

Only a very small part of the city is provided with sanitary sewers, and there appear to be few connections with them. The total area of the city is 5 sq. miles, including marshes, and only 0.4 or 0.5 sq. miles has sanitary sewers, all these being located at the extreme lower end of the city, below the city hall.

The sanitary sewers were designed by Mr. S. M. Gray, M. Am. Soc. C. E., of Providence, R. I., and built with Mr. R. Frank Hartford, of Atlanta, Ga., as constructing engineer. These sewers are operated by a sewer commission, with Mr. R. B. Olney as superintendent. The commissioners are appointed by the mayor. The sanitary sewers were built in 1894 or 1895, and yet Mr. Dingle states that there were less than one hundred connections at the close of 1900. An excuse for failure to connect is the scanty water supply, the pressure being cut down to zero from 1 to 5 a. m. nearly every day, according to a pressure gage in the basement of the city hall.

All the house sewage is lifted by Shone ejectors, of which there are four, operated from a central station. The repairs to these ejectors in 1899 amounted to $3.20, and the total expense for the sanitary sewerage system was $3,743, of which $2,076 was on account of the power station and $1,000 was for the salary of the superintendent of sewers.

There are many surreptitious connections with the storm water sewers, including overflows from "dry wells" or cesspools.

There are 23.53 miles of storm-water sewers or drains, of which 18.03 miles are of brick, with sectional areas ranging from 1½ to 5¾ sq. ft., and 5.51 miles are "tidal sewers," 3½ × 5¾ ft., over all. These tidal sewers were built in the 60's, with floors of 3-in. plank, 13 ins. above mean low water, from end to end. That is, their bottoms were designed to be perfectly level. The mean rise of tide is 5 ft. The theory of the engineer who built them was that as the tide fell the contents of the sewers would be completely discharged, leaving the floor perfectly clean. Practice shows that they must be cleaned once in two years. The work is done by hand. A survey made in 1890 by Louis J. Barbot, formerly city engineer, showed that the profile of the bottom was then very irregular, due to settlement, some of which may have occurred at the time of the Charleston earthquake.

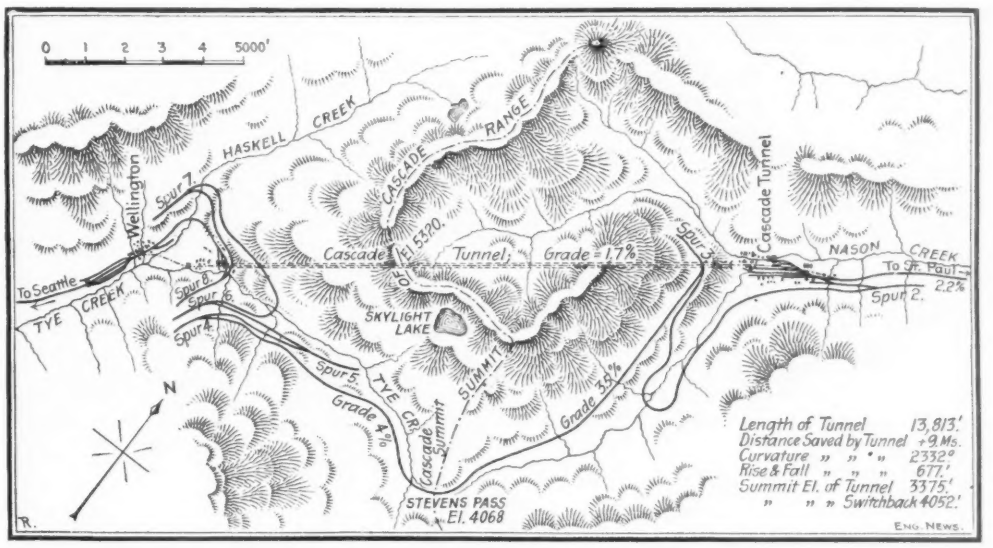


FIG. 1.—MAP OF CASCADE TUNNEL AND SWITCHBACK; GREAT NORTHERN RY.
John F. Stevens, M. Am. Soc. C. E., Chief Engineer.

Theoretically, these tidal sewers should drain out between tides, but their contents seem to assume an inclined plane, at the surface, through lack of time for perfect drainage between tides.

The sewers have 14-in. vertical side walls, 4½ ft. in height above the floor, with a 9-in. brick arch, of 3½ ft. radius turned above. The original plans contemplated the turning of an inverted arch of 18-in. radius, above the 3-in. plank floor.

Some of the lateral drains empty into the tidal drains and some directly into tide water. These lateral drains vary from 8 to 24 ins. and aggregate 29 miles.

The character of the streets of Charleston, paved and unpaved, at the close of 1899 was as follows:

	Miles.		Miles.
Asphalt	0.73	Steam railway tracks and plank	3.03
Cobble	4.84	Cement gravel (natural)	6.26
Earth	34.25	Macadam	0.51
Granite blocks	16.14		
Plank	0.45		
Pyrites	0.62		
Shell	1.62	Total	68.45

The cement gravel costs 40 to 50 cts. per sq. yd., but does not wear well. Macadam is now being used instead, the rock being brought from Columbia. This macadam costs about 70 cts. per sq. yd.

The city scavenger department collected a total of 71,906 cu. yds. of garbage and other refuse in 1899, divided as follows: Garbage, 42,654 loads; sweepings, 6,558; not classified, 5,569; sand fillings, 4,643; paper, 3,827; pavers' cart, 2,286; jute, 2,286; cinders, 1,645; debris, 1,377; grass cuttings, 1,021; minor classified matter, 40 loads.

This stuff is used for filling, selected material being placed near the bay and putrefactive matter being hauled out to the marshes. The city never had a garbage crematory. In addition to the above, 2,066 privy vaults were emptied in 1899.

A franchise for a second water-works system was awarded in 1900. Municipal ownership was desired, but the financial condition of the city not permitting it, arrangements were made to have works built for the city with a scheme for ultimate municipal ownership. A supply of 6,000,000 or 7,000,000 gallons from the Edisto River is proposed. The present supply, furnished by the Charleston Water-Works Co., is from artesian wells.

The city has 12 parks and public squares, with a combined area of 607.68 acres. The largest one, Chicora Park, has an area of 575.3 acres. All the others have areas of less than ten acres each.

Commissioners of Bathing Houses were appointed some years ago, to establish sea bathing places. One beach bath was provided, but the wooden dressing compartments were blown away and never replaced.

The only cemetery owned by the city is a Potter's Field, in which 410 burials were made in 1899; 395 blacks and 15 whites.

The city has fire alarm and police telegraph systems. During 1899 an immense auditorium was built, having a seating capacity of 7,000.

The city has a steam disinfecting plant, in charge of the health department. During the summer months of 1899 the health department employed four carts daily in the distribution of free disinfectants, including quick lime, chloride of lime, copperas and carbolic acid.

Dr. H. B. Horbleck is health officer and Dr. Robert Wilson is bacteriologist of the city health department. Mr. J. A. Smyth is mayor of the city.

THE CASCADE TUNNEL; GREAT NORTHERN RY.

By John F. Stevens, M. Am. Soc. C. E.*

The Pacific Extension (main line) of the Great Northern Ry., which was built in the years 1891 and 1892, from a junction at Havre, in northern Montana, to Puget Sound, at Everett, and thence to Seattle, Wash., crosses the main divide of the Rocky Mountains at an elevation of 5,215 ft. above sea level. Thence it follows the waters of the Flathead River, which is a branch of Clark's Fork of the Columbia, to the Kalispell valley, at an elevation of 3,580 ft.

From Kalispell it crosses the Cabinet Mountains, which are spurs of the main range of the Rocky Mountains, at an elevation of 3,930 ft., and descending, reaches the waters of the Kootenay River, which it follows to a point about 100 miles northeast of Spokane, Wash. Leaving the Kootenay, it runs southwest through a low divide, to the Pend d'Oreille River, which is one of the large branches of the Columbia River. Thence it strikes southwest to Spokane, at an elevation of 1,900 ft., thence west across the Big Bend of the Columbia River, where it reaches an elevation of about 2,300 ft. above sea level. It then descends gradually, reaching and crossing the Columbia River in central Washington, about 160 miles west of Spokane, and at an elevation above sea level of 650

*Chief Engineer, Great Northern Ry., St. Paul, Minn

ft. Thence it follows up the valley of the Wenatchee River, a tributary of the Columbia, and crosses the Cascade range of mountains through Stevens Pass.

The mountain grade on each side of the pass on permanent line is 116 ft. per mile (2.2%), equated for curvature. After crossing the summit of the Cascades, it descends, following the Skykomish and Snohomish rivers to tide water in Puget Sound, at Everett, Wash.

The crossing of the summit proper, of the Cascades, since the construction of the line, has been effected by means of a switchback, which was described and illustrated in Engineering News, May 3, 1900. Briefly, the switchback consists of eight branches, or legs, each terminating in a spur 1,000 ft. long. The grade of the switchback legs on the east side of the mountain is 3½%, and on the west side 4%, both equated for curvature. The maximum curvature is 12°. This switchback was built merely as a temporary line, it being intended at the time the line was completed to immediately proceed with the construction of a long tunnel to do away with the switchback. Business conditions, however, did not justify the commencement of such a tremendous piece of work between 1892 and 1897, but in the latter year orders were given to commence the construction of the tunnel, and push it as fast as possible to completion, which has been done, and the tunnel is now finished.

The map and profile in Fig. 1 show the situation, and on the same cut are given the plans of the two working camps. The length of the tunnel as constructed is 13,813 ft., of which about 400 ft. (or 200 ft. at each end) is an extension of the permanent lining, to take the place of the wooden snow shed, but the length of the tunnel proper, from face to face of portals, is 2.61 miles. The width in the clear, inside of the permanent lining, is 16 ft., and the height from top of rail to bottom of arch is 21 ft. 6 ins.

The original preliminary surveys for this tunnel were made in 1892, and in 1896 the line was revised, and the east end of the tunnel tangent was thrown south a short distance, and the line as thus established became the center line of the tunnel. The length of the tunnel was measured with steel tape and plumb-bob, and levels were run over the switchback pass. During the summer months of 1897, 1898 and 1899, while the tunnel was under construction, the center line work was many times carefully rechecked, levels were again run over the switchback, and checked and rechecked, until practically there was no error apparent.

As will be seen from the accompanying profile, the mountain over the tunnel has two peaks, the western and highest one being about 2,150 ft. higher than the west portal, and the eastern peak being about 1,750 ft. higher than the east portal. Transit points were established on each one of these peaks, from which could be seen points just outside of each portal. These points were checked by repeated observation under the most favorable climatic conditions, a Buff & Berger transit being used. Timber towers 16 ft. high were erected at each of these summits, in the center of which were secured gas pipe targets, 2 ins. diameter and 20 ft. high, so as to be seen in winter above the deep snow. These targets were plumbed occasionally, by dropping a plumb line through the center of the gas pipe to a point on the tack below. Intermediate foresights were located along the mountain sides, to be used when the summit targets were obscured by clouds. Permanent transit points were built at each portal, lifted somewhat above them, and were roofed over to protect them from snow. From these portal points the center line was projected into the tunnel.

The length of the tunnel was obtained by direct measurement, as this method seemed to be preferable to any system of triangulation. Measurements were made along the slope of the mountain with a 400-ft. steel tape, measurement points having first been established, as nearly 400 ft. apart as the nature of the ground would permit. These points were placed either on high stumps, on braces nailed to trees, or on plugs driven in holes drilled in the rock cliffs. The elevations of these measurement points were then carefully taken with a level. The tension on the tape was regulated by a spring balance, and the temperature noted at each end of the tape. Measurements were usually made on cloudy days, when there was little wind. From the slope measurements corrected for temperature, and the vertical distances between stations, the horizontal distances were calculated. A base line was laid out at the west portal, with a standard 100-ft. steel tape, in order to arrive at the proper tension to be applied to the 400-ft. tape, and fraction thereof, 62° F. being assumed as normal temperature.

Inside of the tunnel, the measurements were carried along the plumb posts, and after the completion of the concrete lining, each station was marked by plugs driven in holes drilled in the concrete walls. Bench marks were placed in a similar manner. Transit points were placed in the key segments of the timber arch. Platforms were erected about 800 ft. apart, at the elevation of the wall plates, with two independent floors a few inches apart, one to support the transit and the other to support the transitman. Muck and concrete trains passed under these floors, and in no way interfered with the work of the engineer. Electric lights, carefully centered, served as backlights.

The formation of the mountain and the material encountered, with the exception of 500 ft. of soft ground at the west portal, was medium hard, light grey granite, very largely seamed, and the seams were often loose and filled with a thin vein of talc, which broke the bond. Owing to this fact, and also to the presence of large quantities of water in all the seams, the material was both difficult and delicate to handle. Occasional bunches of black slate cut the formation of these veins, but were only 12 to 24 ins. in thickness, and always carried a quantity of water, adding materially to the difficulties of excavation. Added to this, some of the granite, although hard to drill and blast, would disintegrate quite rapidly on being exposed to the atmosphere, so that it was necessary to put in a temporary lining of timber throughout the entire length of the tunnel.

For the first 500 ft. at the west portal, the tunnel was driven through a slide composed of gravel and large boulders. This ground was heavily impregnated with water, and the pressure from above was tremendous. The presence of the large boulders made it difficult to drive poling boards, and a hole a few inches in diameter, if left open, would soon let in sand enough to fill the heading. During April, 1898, the progress in this material was less than 1 ft. per day, and sometimes for days it seemed as though no headway was being made. To carry this heavy ground required three concentric sets of timbers, as well as tie-rods, connecting the wall plates.

The methods of construction are illustrated in Fig. 2. The ordinary American system of tunnel excavation was employed. The overhead heading was taken out to the full size of the rock section, 10 × 20 ft., and the bench taken out in two lifts. Rock from the heading and top bench was wheeled in barrows, out onto a large traveling carriage called a "jumbo," where it was dumped through chutes into the muck cars. Material from the lower bench was shoveled directly into the cars. On a secondary floor, under the main floor of the "jumbo," was a hoist operated by compressed air, which was used to load large pieces of rock, some of them weighing six tons, on the flat cars. This obviated the necessity of blockholing large pieces of rock, to enable them to be handled. This cable and hoist was also used to move the "jumbo" back from the rock face, when blasting was to be done. Compressed air, at 100 lbs. pressure, operated drills, hoists and pumps, with the exception of one large pump, which was operated by electricity. Four vertical columns in the heading carried six 3¼-in. Rand "Slugger" drills. From 24 to 28 holes, 12 ft. deep, were drilled in the breast, and fired by electricity, in three rounds. Holes were drilled to lift the top bench, and vertical holes for the main, or lower bench, enough to break the rock to subgrade. Altogether an average of fourteen 3¼-in. drills were used in each heading and benches.

All hauling out of muck, and hauling in of concrete, was done with electric motors, of which eight were in service. Six of these were constructed at the tunnel machine shop. One of these motors hauled loaded trains of from 16 to 20 dump cars, of 1 cu. yd. capacity, up the 1.7% grade, at 10 miles per hour. The electric motors and muck cars were of 2-ft. gage, and were operated on double track, made of second-had 50-lb. rails, laid on wooden ties. The tracks were provided with split switches, electric target lamps, etc., and a great degree of the success which was met with

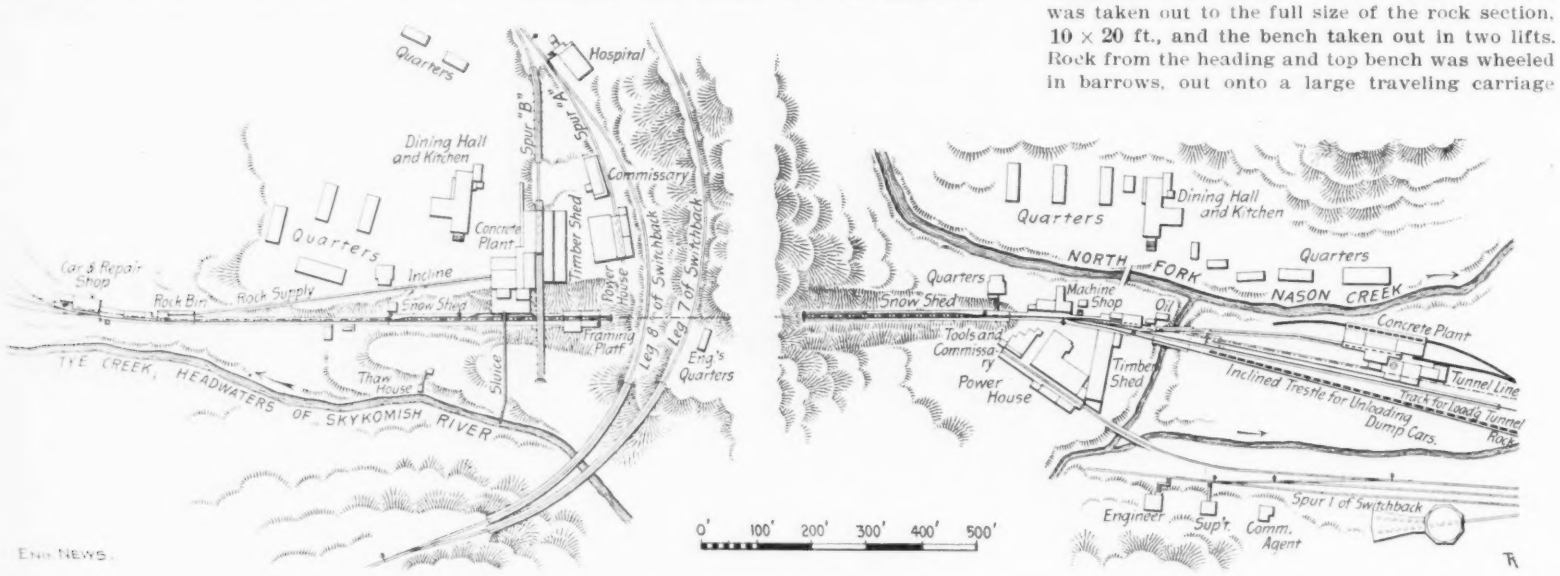


FIG. 2.—PLANS OF CONSTRUCTION CAMPS AT EAST AND WEST PORTALS OF TUNNEL.

in handling this material in such long distances was due to the heavy material of which the muck trucks were constructed, and the care exercised in putting them in.

All the works in and about the tunnel, as well as the boarding camps, offices, etc., were lighted with incandescent lights, and especially those parts of the tunnel where actual excavation was being done. Nearly 1,000 16-c.p. lamps were used. Electricity for the operation of trains and lighting of camps was generated by eight dynamos, aggregating 300-K-W. minimum capacity. These dynamos were belt-driven from four automatic high-speed steam engines.

The foul air was exhausted from the heading through 24-in. galvanized iron pipe, by means of a No. 9 Sturtevant fan, running at 1,700 revolutions per minute. The exhaust pipes were made in 16-ft. sections, bolted together by means of cast iron rings, with friction paper washers between the rings, thus insuring almost air-tight connection. In general, the ventilation was excellent, the men usually being able to return to work in from 10 to 20 minutes after a blast had been fired. The large amount of air liberated from drills, hoists and pumps, added materially to the supply of fresh, cool air.

The grade through the tunnel is 1.7°, the maximum grade outside being 2.2°. An allowance of 0.5° for wet rail was made in the grade of the tunnel. The summit being just east of the east portal, necessitated the pumping of all water from the east end, during the driving of the tunnel, and this added materially to the difficulties experienced. During the last year of the work an average of over 1,000,000 gallons daily was raised 110 ft. vertically, through 6,000 lin. ft. of 8-in. pipe. Large pumps driven by compressed air were installed, these plants being in duplicate, to avoid delay or danger from accident. Considerable annoyance was caused by the freezing up of the air valves on the pumps, which was partly eliminated by the introduction of traps, but it was not considered serious enough to reheat the air. A large body of water was encountered shortly before the completion of the excavation, and an immense electric pump was installed, which materially assisted in keeping the water under control. At the west end, of course, no pump was required, as the water was carried by the side ditches to the outside.

Large power houses were erected at each portal. At the east side the power house contained one Ingersoll-Sergeant duplex compressor, 18 × 24 ins.; one Ingersoll-Sergeant straight line air compressor, 18 × 24 ins.; one Rand duplex Corliss valve compressor, 20 × 36 ins.; one Buckeye high-speed engine, 12 × 16 ins.; one Chandler & Taylor high-speed engine, 13 × 14 ins.; six 150-HP. boilers with pumps, water heaters, dynamos and fans.

At the west portal power house was installed one Ingersoll-Sergeant duplex compressor, 18 × 24 ins.; one Buckeye high-speed automatic engine, 12 × 16 ins.; one Chandler & Taylor high-speed engine, 13 × 14 ins.; and three 150-HP. boilers, with pumps, water heaters, etc. In addition to this machinery there were the dynamos, fans, etc., as well as the concrete plants, which were erected in independent buildings. The compressed air for the drills was conveyed from the receivers in the power houses, through a 6-in. wrought-iron pipe to the heading, where it was distributed through manifolds to the drills, air hoists, pumps, etc.

As before mentioned, the entire tunnel was temporarily lined with timber, each set comprising vertical plumb posts and a five-segment circular arch, as shown on the plans. Nearly all of this timber was removed when the permanent lining was constructed, only such timber being allowed to remain as it was deemed unsafe to remove, and this only where it is constantly exposed to water. In all such places the section was excavated large enough to allow of this being done.

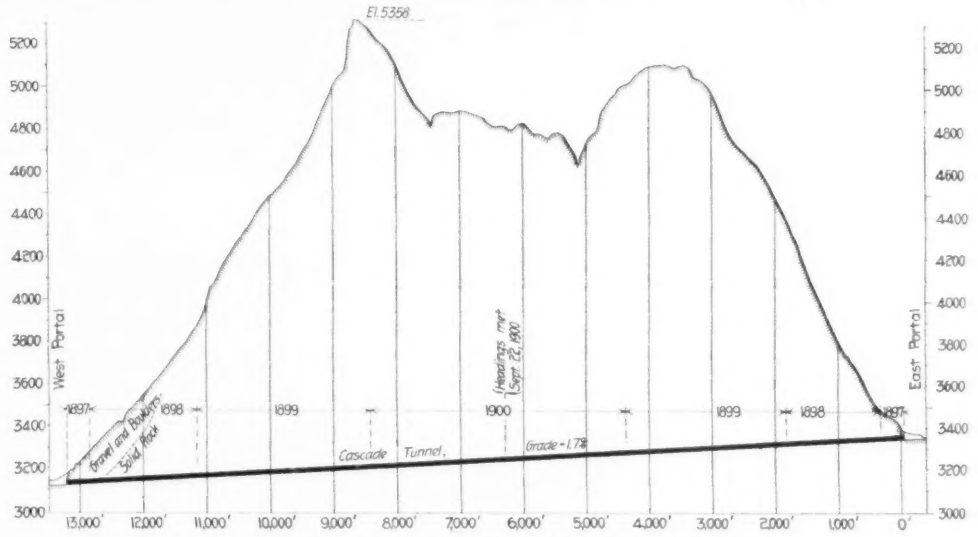


FIG. 3.—SECTION OF MOUNTAIN ABOVE TUNNEL LINE.

The tunnel is permanently lined throughout its entire length with concrete, this lining being nowhere less than 24 ins. thick, and in places 3½ ft. thick. Where the section was larger than would admit of solid concrete, it was backfilled with spawls and broken stone, the result being a monolith of concrete from portal to portal, which, so far, has not shown a crack.

The methods of prosecuting this part of the work are thought to be new in some respects. It was imperative that the placing of the concrete should not interfere in any way with the progress of driving the tunnel. To insure this result, all work possible connected with the concreting was done from a platform at the elevation of the wall plate, allowing muck trains to and from the heading to pass underneath.

This platform was erected in sections 500 ft. long and reached by an incline up which the cars, loaded with concrete, were hauled by an air hoist and cable, which cable also delivered the concrete at any desired point along the platform. While each 500 ft. of tunnel was being concreted the next 500 ft. of platform in advance was being erected, with its approaching incline, so there was no delay in the work, and sidewalls were built in alternating sections of 8 to 12 ft., the weight of the timber arch thus being gradually transferred from the plumb posts to the side walls. Arch sections were built in 12-ft. sections, about 10 of these sections being used at each end of the tunnel. Centers were built up with plank 4 × 16 ins., with no radials. These 12-ft. sections were spaced so that when the concrete had set each section was advanced 12 ft. on dollies, and jacked up to proper elevation.

Complete concrete plants were installed at each portal, advantage being taken of the side hills of the approach into the mountain, so that all material could be handled by gravity. Each plant was equipped with No. 6 Gate crushers, rock screens 40 ins. by 8 ft., and screw concrete mixers 16 ins. by 16 ft. Large storage bins for crushed rock, sand and cement were built adjacent to the mixing plant. Concrete was mixed in proportions of 1 part Portland cement, 3 parts sand and 5 parts broken rock. The rock for the concrete was obtained from the best rock in the tunnel, being loaded there in the ordinary muck

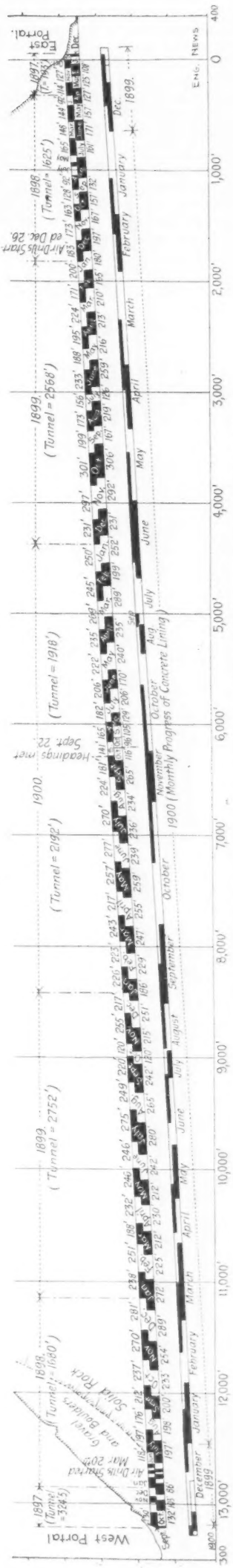


FIG. 4.—MONTHLY PROGRESS PROFILES OF WORK ON EXCAVATION AND ON CONCRETE LINING.

cars, brought to the outside by the electric motors, and then dumped into other cars below the level of the muck cars. These cars were hauled to the top of the concrete building by means of hoisting engine and cable. Then the rock was dumped upon the crusher floor, where it was carefully sorted by men to avoid danger from pieces of unexploded dynamite. It was then run through the crushers, washers and screens into the bins, thence to the mixing floor, and after the concrete was mixed, it was dumped through the floor into concrete cars on the level of the muck or tunnel tracks. Thence it was hauled by motor to the work inside of the tunnel, and delivered at the foot of the incline, where it was hauled onto the concrete platform by the hoists and cable, as before explained. Upon reaching the platform the concrete was dumped onto the platform, from which it was shoveled either into the forms enclosing the sidewalls or onto the arch centers, where it was properly tamped. About 95,000 barrels of Portland cement was used in lining the tunnel, an average of seven barrels per lineal foot. At different points along the side of the tunnel, refuge bays, or places for hand cars, were excavated in the rock, concrete lined arches being turned in the same.

By the construction of this tunnel, about nine miles of distance, as compared with the switchback, are saved, and 2,332 ft. of curvature, as the tunnel proper is on a tangent. The rise and fall saved is 700 ft. The climatic conditions entered largely into the relative merits of the switchback and tunnel. The snowfall in the Cascade range is excessive, and it was difficult and expensive to remove the snow from the switchback tracks. During the winter of 1897-1898 the accumulated snowfall at the summit of the switchback was 140 ft., 20 ft. on the level being recorded at one time. This factor of expense and delay to traffic by operation of the switchback is a large one, and estimated as the largest determining factor in favor of the tunnel line. Then, too, a switchback has its limits in the amount of traffic that it can handle, and under the present business conditions the limits of this particular switchback were rapidly being reached.

The tunnel excavation proper was commenced Aug. 20, 1897, and completed Oct. 13, 1900. The average monthly progress in the tunnel was 350 ft.; average daily progress, 11.53 ft. The best year's work since June 1, 1899, to June 1, 1900, was 5,575 ft.; the monthly average during the same time being 464.7 ft., and daily average, 15.3 ft. The best month's progress in excavating the tunnel was November, 1899, 527 ft. The best week's progress was in March, 1900, 143 ft.

The work of concrete lining the tunnel was commenced Nov. 17, 1899, and completed Nov. 17, 1900. The average monthly progress was 1,115 ft.; the best monthly progress, 1,713 ft., and the best daily progress, 32 ft.

While no claim is made that the work of excavating is in advance of previous efforts in the same line, it is fair to say that it is well up to the average. Mistakes of the usual kind were made in installing the plant; that is, of not providing power enough, as the work of pumping water at the east end was underestimated, and it was not until the summer of 1899 that a proper amount of power was provided, after which, as the progress profile shows, the advance was much more rapid. The progress of the work was also hampered from start to finish by the quality and quantity of labor which it was possible to secure. The labor question in the Western states, and especially near the Pacific coast, is always a serious one to contract. This includes the management of the boarding camps and stores. The time and accounts of all officers, foremen and laborers were carried on the engineers' rolls.

The work of constructing this tunnel has been carried out under the direction of H. W. Edwards, M. Am. Soc. C. E., Resident Engineer, G. N. Ry., with M. E. Reed as Assistant Engineer, and A. L. Andrews as Superintendent of Construction. The results arrived at would seem to indicate that the work of engineering has not suffered in their hands, as on completing the excavation, and checking lines, levels and distances, the following errors were found: Error in alinement, 0.020 ft.; error in grade, 0.019 ft.; error in distance, 0.170 ft. This certainly goes to show that great care was exercised in instrumental work.

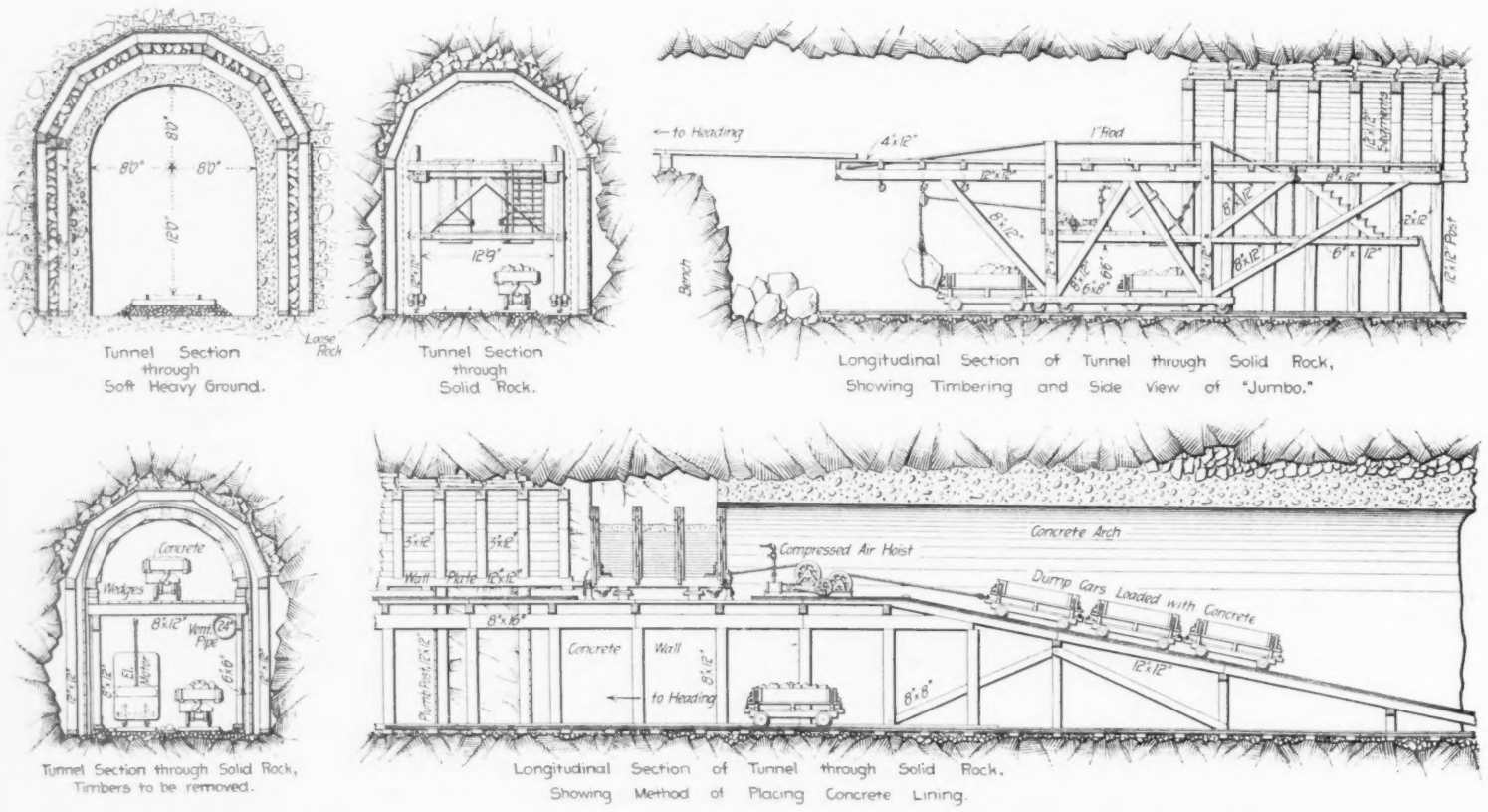

Tunnel Section through Soft Heavy Ground.
Loose Rock
Tunnel Section through Solid Rock.
Longitudinal Section of Tunnel through Solid Rock, Showing Timbering and Side View of "Jumbo."
Tunnel Section through Solid Rock, Timbers to be removed.
Concrete Arch
Compressed Air Hoist
Dump Cars Loaded with Concrete
Concrete Wall
to Heading
Longitudinal Section of Tunnel through Solid Rock, Showing Method of Placing Concrete Lining.

FIG. 5.—CROSS SECTIONS OF TUNNEL AND LONGITUDINAL SECTIONS, SHOWING EXCAVATING AND LINING SYSTEMS.

THE COMMERCIAL ENGINEER.*

By M. S. Ketchum.†

For the purpose of this article a commercial engineer will be defined as an engineer who is both a contracting agent and a designing and constructing engineer. Having served in the capacity of commercial engineer for a well-known firm of bridge builders and manufacturers of steel and iron structures in the north and northwest, the writer will for the most part confine what he has to say in this paper to that particular line of work.

We will assume that the commercial engineer has been sent by his firm to a western state, where a mining company is contemplating the erection of a new smelter to secure, if possible, the contracts for the buildings, hoppers, structural materials, furnaces, etc., and will describe somewhat in detail the different steps that he will take. Arriving at his destination, the engineer goes at once to the office of the mining company and meets the manager. The success or failure of his mission will often depend upon the first impression made, and he should use great care in sizing up his new acquaintances, for only by practice and exercise of tact can a man learn to be all things to all men, making a favorable first impression on each. He should, of course, be familiar with the subject under consideration, and should make it a point to leave that impression on the mind of the officials. He should be familiar with the methods of handling and treating the ore and slag, and with the type and style of the buildings and furnaces, etc. Having gotten the data for the structure and having found what the ideas of the man in charge and the manager are, in order that he may incorporate them in his plans, the engineer proceeds to make a design.

*From a paper read before the Illinois Society of Engineers and Surveyors.

†Assistant Professor of Civil Engineering, University of Illinois, Champaign, Ill.

Preliminary designs are usually only general show plans with occasionally a few sketch details, showing special or novel constructions. Usually the stresses in the trusses, posts and braces and the sections of the various members are shown in the plan, though the writer has frequently seen designs submitted without a stress or section marked, the capacity of the structure being indefinitely covered by a very ambiguous specification accompanying the plan. This method gives a disreputable company a great advantage, though it may be to the advantage of the reputable company if they are dealing with unscrupulous customers, as it prevents the customer from sending the design to a competitor, who has not gone to the expense of getting up a design, or who has not the facilities for making one. There is ordinarily very little danger of this being done, though the writer has had this very thing happen to him several times, the most notable case being in British Columbia a couple of years ago, where the manager sent plans which had been prepared at considerable expense of money and time to a competing firm who offered to do the work at the same price, but guaranteed an impossible delivery and were given the contract. The manager admitted that he had violated his trust, but in reply to a bill rendered for plans suggested that action be brought in the courts, which effectually settled the controversy. No general rule can be given as to how complete to make the plans in any particular case as it will depend on conditions which can not be foretold and the engineer will have to depend upon his judgment.

After completing the design the estimate is made. Here as well as in designs the engineer must be familiar with details, economic sections, and shop and erection methods. The estimate is usually made by taking the weight of the sections marked on the general plan, the lengths being scaled or read off, and then adding a certain per cent. for details in each member. This percentage varies with the makeup of the member, the style of details and connections, and the length, between very wide limits. For example, the percentage of details for a post composed of two channels placed back to back with side lacing will vary from 20 to 75%, the greater the length the smaller the percentage with similar details. This wide range gives the estimater a chance to use his judgment, and though the separate items may be considerably in error, the final preliminary estimate should not ordinarily vary more than 2% from the shipping weight. The estimate should always be checked up by comparing it with the weight of similar structures already built.

Having the weight estimated the next thing to do is to estimate the cost. The plain material, punched material, posts, trusses, etc., should be put in separate classes for convenience, a separate cost price being used for each class. The cost for each class of material is found by adding together the mill cost, shop cost, cost of transportation, and cost of erection. Shop costs vary from 1-10 ct. per lb. for plain punching to 4 or 5 cts. per lb. for complicated blast-pipe work, while the shop cost for ordinary plain mill buildings is about ¾-ct. per lb. If the engineer has not been instructed with reference to freight rates he must determine them for himself, care being used to use the proper classifications. The cost of erection will depend on the character and location of the work and for ordinary conditions will cost from $5 to $10 per ton. General specifications as to materials and workmanship should be prepared and submitted along with the bid.

In case the bid is accepted a contract is drawn up and signed. In this contract the engineer should state clearly what he intends to furnish, what the owner is to furnish, the time of completion, and the amount of compensation with the method of payment. It is usual to have a certain part of the price, usually 50%, payable when the material is loaded on board cars at the factory, the mining company to pay freight bills and pay-rolls, and the remainder to be paid on completion and acceptance. The contract and specifications should be brief, clear and concise. The best form of contract that the writer has ever seen was simply a formal written proposition by the agent to furnish the structure according to plans and specifications within a certain specified time for a specified sum paid in a specified manner. This should be made in duplicate, signed by the agent for the firm and accepted by the manager for the mining company. This is a form of contract that means what it says and requires little knowledge of law to prepare. Great care should be used not to promise to do more than can be carried out, and penalty contracts should be avoided whenever possible. If it is necessary to take them, be sure to get a price sufficient to pay for the risk and get as long a time as possible. In sending in the data care should be taken to specify the kind of anchor bolts to be used and who is to furnish and set them, so that they may be sent by local freight if necessary, the sizes and styles of windows and doors, the finishing details at corners, gables, etc., and any other information that may be necessary or of value.

During the process of erection the engineer will have general charge of the work, will advise the foreman, handle the pay-rolls and see that everything goes along smoothly and that everything is going to be satisfactory to the company. It will not be necessary for him to make more than an occasional visit unless things go wrong, either due to lack of skill in the foreman, mistakes in the drafting office or shops, or both, in which case it may be necessary for him to remain constantly on the ground and take personal charge. If an ordinary foreman once loses faith in his plans he will be liable to decide that everything is wrong, and will want to cut off the members or punch new holes on the least provocations. The writer has frequently found it necessary to superintend the putting in of stiff bracing in order to keep the foreman from chopping it to pieces. The engineer should not ordinarily interfere with the foreman in handling his men, the foreman and not the engineer being in charge of the men, and all orders should be given to him direct. The last, though not the least, important thing to be done is to settle the business up, adjusting questions in dispute and getting final payment.

From the above it will be seen that the duties of the commercial engineer in this line of work are varied and important. The problem constantly presented to him is, not what is the very best type of construction or best solution of the problem, but what is the most economical type of construction, or how can the problem be solved so that the cost shall be a minimum and the profit to his firm a maximum. There is very little difference in shop costs between the different firms engaged in manufacturing similar products and practically the only line of competition left open is that of design. The engineer must therefore always design economically but safely, remembering that economy occupies narrow limits, bounded on the one side by danger and the other side by extravagance, and that neither the danger nor extravagance lines are well defined. The success of a commercial engineer is determined not by the amount of his contracts, but by the profits accruing therefrom.

Most firms prefer men for their engineering representatives who are college graduates with several years' experience in the drafting office or engineering department of some bridge works. Other things being equal, preference is given to young men, for the reason that they can and will adjust themselves to conditions more readily, can endure more hardships and will obey orders better than older men. Of all the necessary qualifications that go to make a successful commercial engineer, the art of obeying orders is probably the most important. It is essential that the engineer be able to make a neat drawing under any and all conditions. He must not only be able to make a general design, but must be familiar with both shop and erection methods so that details will work out in a satisfactory and economical manner. He must be versatile and full of resources. It is necessary that he solve the problems proposed to him quickly and in a way that will create confidence and be practicable. It is impossible to carry many reference books and he should be so familiar with the technical part of his work that he can readily work out the stresses and design anything from a cast-iron column to a gallows frame or a draw-bridge with the aid of a manufacturer's handbook, and what he carries in his head. He should be progressive but not reckless and should always remember that the strength of a structure is measured by the strength of its weakest member. He should have a practical business education and should possess the faculty of making a good impression upon those whom he meets, which means that he must have considerable strength of character.

The commercial engineer, being engaged in selling, is sure to have his services appreciated in a more substantial way than those of a designing or constructing engineer. In fact, under the present conditions the successful man can set his price and get it if he uses the same business tactics in getting a position for himself that he does in getting a contract for his firm.

The time when a shrewd business man without an engineering education could plan and carry through great schemes for building bridges or developing water power is passing and the man of the future who would get the promoter's share in enterprises of this sort must be both a business man and an engineer. With the expansion of the trade of this country, the demand for commercial engineers will necessarily increase and the young engineer that expects to be one of those who will profit largely by this expansion should be preparing himself for the opportunities that will only come to him if he is ready for them.

Our universities offer opportunities for special training in engineering, but the writer knows of no educational institution in this country or in Europe that is offering training in all lines required by the commercial engineer, although a few colleges of commerce have been established in the latter country. As a closing thought, the writer would suggest the following for your consideration: In view of the present importance and future prospects for men of the type described, does it not look like there was a real need for the establishment of a course in commercial engineering in our technical schools and universities

RAILWAY CONSTRUCTION IN GREECE.

By H. L. Geissel.*

The recent annexation of the Transvaal to the British Crown through Lord Roberts has once more directed public attention to the Greek railways. Strange as it may appear, the South African war has a certain influence upon the extension of the Hellenic railway system, for it depends upon the termination of this war as to when work on the projected lines in Greece shall be started.

On March 22, 1900, a contract was signed between the Greek government and an English company known as "Eastern Railway Construction Syndicate, Limited," according to which the latter has undertaken to build the railroad from Piraeus to Demerti, in Thessaly, on the Turkish border. Work was begun some years ago on this road by a Greek company; but the company failed and work was abandoned. According to a special stipulation provided in the above-mentioned contract, the government is bound to extend this line to Larissa. It was further stipulated that the Eastern Railway Construction Syndicate should form a new company within three months after the close of the war in South Africa, to be known as the "Hellenic Railway Co.," with 10,000,000 drachmas ($1,934,000) capital. This company is to construct the line to the Turkish frontier, as well as two branches, one from Skimatri, in northern Bœotia to Chalkis on Euboea, and the other from Lianokladion to Lamia, with prolongation to Aja-Marina and Stylis, on the northern coast of the Bay of Lamia. The trunk line Piraeus-Demerli is to be completed within four years from the date of the formation of the Hellenic Railway Co.; the term of the concession is 99 years, but the Greek government has reserved the right to buy the line after 25 years of operation.

A dispute has now arisen between the Hellenic government and the administration of the Eastern Railway Construction Syndicate as to the termination of the South African war. The government of Greece is of the opinion that with the annexation of the Orange Free State and the Transvaal the war is officially over, and at the same time the Greek government insists upon the work on the railway being started at once. The Eastern Railway Construction Syndicate, on the other hand, claims that the war is far from being ended, and that the stipulations of the contract entered upon do not in any way demand the formation of the Hellenic Railway Company after the South African republics had been annexed, but most clearly state that this company must be formed within three months after "the close of the war."

The reasons for this somewhat peculiar stipulation could be read between the lines: The Greek government, as well as the Eastern Syndicate, when entering upon the contract, worked under the well-founded impression that rolling stock, as well as railway material, could be obtained cheaper after, than during the war, hence this clause.

It is not improbable that the matter will be brought before the courts, and we may then have an opportunity to learn whether the South African war is officially over or not.

There is no doubt that the construction of the line to the Turkish frontier will have the greatest influence upon the agricultural development of the districts and provinces it crosses. It is also thought in Greece that this line will largely increase the commercial intercourse between Greece and Turkey, and will especially have a great influence upon the mail traffic between Europe, India and the Far East, as it is generally accepted that the mail would then be conducted via Athens instead of Brindisi. The distance between Port Said and Piraeus is 373 miles shorter than that from Port Said to Brindisi, and the saving in time for mail via Piraeus would be 24 hours for Vienna, 20 for Berlin, 26 for St. Petersburg and 14 for Brussels.

*233 South 4th St., Philadelphia.

THE HARVARD ASTRONOMICAL STATION, at Mandeville, Jamaica, is soon to have a large horizontal telescope, the foundations and building having been recently completed under the direction of Prof. W. H. Pickering, of Harvard College.

A PROCESS FOR THE MANUFACTURE OF METALLIC silicon has been patented by Bernhard Scheid, of Frankfort-on-the-Main, Germany. He first grinds five parts of quartz, two parts of carbon and about one part of sodium soluble glass in a ball mill. The mixture is then heated in an electric furnace to a certain temperature, producing under the proper conditions silicon without volatilizing the same and avoiding the production of silicon carbide.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXI-XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

In our issue of Nov. 15, in discussing state road improvement work, we urged that attention should be given to the improvement of ordinary dirt roads, as well as to the building of high-class macadamized roads. It is of interest in this connection to note that in the annual report of the State Engineer of New York, abstracted in another column, it is announced that this policy will be definitely adopted in future work of road improvement in New York carried on by aid of the state appropriation. In the three years past, half a million dollars has been spent in New York under the state road law, of which half was paid by the state and half by the counties in which the roads are located. The result has been about 53 miles of high-class macadamized roads, the cost averaging thus over $9,000 per mile. It is recognized that in a large part of the state no such expensive roads can be afforded or are justified by the traffic upon them, and a part of the state appropriation will, therefore, be spent in future in improving ordinary roads without macadamizing, the work being carried out in such a manner that the grading and ditching will be so much toward the construction of a macadam road, should that improvement be found advisable through increased traffic in later years. The total cost of such improved roads is estimated at $2,000 to $3,000 per mile; and we think it probable that in practice an even smaller sum may be found sufficient. The State Engineer deserves hearty commendation for this common-sense departure from past precedents. All attempts to interest the farming communities in good roads which cost nearly as much per mile as a standard gage railway are pretty sure to fail; but improved roads at a third or a quarter of this cost will be much more likely to command their support.

A bill to regulate street railways in Illinois has been drafted by a street railway commission of the board of aldermen of the city of Chicago, for introduction in the State legislature. As the bill embodies some of the most advanced ideas relating to street railway franchises, and also to municipal ownership, an abstract of it, and of the accompanying report of the committee, is given elsewhere in this issue. The main features of the bill are: Full local control of street railway service, with State control of capitalization and accounting and publicity of accounts; short term franchises; permissive municipal ownership, but with limitations as to the city's liability for bonds issued to attain that end; and a referendum which is permissive as to popular votes on franchise grants and mandatory in case of municipal ownership, or in case a franchise is to be granted where petitions for the same, signed by over one-half the frontage for each mile of tracks, is not filed before the franchise is granted. While many of the foregoing are what we have termed advanced ideas, they are drawn in a manner designed to prevent hasty and inconsiderate action. Probably the bulk of adverse criticism will center around the authorization of municipal ownership on any terms and, on the other side, the limitations imposed on the financing of municipal street railways will very likely be objected to.

Perhaps the most remarkable development in the field of steam engineering that has taken place in recent years is in connection with the design of propelling machinery for the so-called torpedo-boat destroyers. With the exception of the locomotive, no other type of steam engine has been made to develop such great power within such small limits of space and weight. The value of these phenomenally fast vessels as weapons in naval warfare is an extremely doubtful quantity; but the methods by which their remarkable development has been effected are of interest to engineers generally, for many of the problems which have been solved there are closely allied to those which must be met in the further advancement of steam engineering in other fields.

Elsewhere in this issue we present a recent paper before the Institution of Civil Engineers, in which the latest type of propelling machinery used in vessels of this class is described, and progress up to date is summarized. While a vast amount of literature has been published, especially in foreign journals, concerning torpedo-boat construction, the paper by Mr. Brown is the best summary of practice in this field which we have ever seen and will be found not only interesting but valuable for reference.

Close upon the announcement of the practical union of the Great Northern and Chicago, Milwaukee & St. Paul railway systems, comes the news that the great consolidation of anthracite carrying railways, carried out in 1892 by A. A. McLeod and shortly afterward dissolved through hostile court decisions and weak financial support, has again been completed. This consolidation is the union of the Reading, Lehigh Valley and Central Railroad of New Jersey systems. The combined properties will constitute a railway system about 3,500 miles in extent and representing a total capitalization, in stocks and bonds, of about $375,000,000.

The consolidation of the Great Northern and Chicago, Milwaukee & St. Paul interests creates a system with a total extent of nearly 12,500 miles, but its total capitalization is a little less than that of the coal-carrying systems above described.

Coincident with the announcement of these latest huge additions to the list of railway consolidations is the appearance of the Interstate Commerce Commission's annual report, in which the grave problems which the progress of railway consolidation is creating are plainly set forth. During the period from July 1, 1899, to Nov. 1, 1900, there were absorbed or consolidated in various ways, 25,311 miles of railway. These figures, it will be noted, do not include the huge consolidations above mentioned.

The effect of these consolidations is unquestionably to eliminate competition as a factor in railway traffic. That, indeed, is one chief purpose in their consummation. As the Interstate Commerce Commission points out, moreover, the removal of competition is in many respects beneficial to the public. It enables the railways to reduce expenses and to maintain rates uniform to all, stopping the discriminations in favor of large shippers, which have been the bane of the competitive system.

But, on the other hand, with competition absent, what protection has the public in the matter of rates? What shall prevent the railway managers from charging "What the traffic will bear," and all that it will bear?

As the Commission well says:

> If competition is taken away nothing remains (to keep down rates) except the force of popular opinion and the feeble restraints of the present law, which are of little effect when directed against slight and gradual advances. It will lie within the power of two or three men, or at most a small group of men, to say what tax shall be imposed upon the vast traffic moving between the East and West.
>
> It is idle to say that freight rates cannot be advanced. During the past year they have been advanced in every part of this country, upon a vast volume of traffic. It is equally idle to say that they will not be advanced. It is both human nature and the lesson of history that unlimited power induces misuse of that power. Railways are not combining for the purpose of "extortion and abuse," but none the less should the people provide some protection against that possible result of the combination.

Continuing, the Commission shows how advances in rates have been effected by changes in classification during the past year, such advances amounting to 15% to 40% or more of the old rate. Referring to the Buffalo-New York grain pool, it is shown that the pool probably makes it possible to maintain grain rates from 1 ct. to 2 cts. per bushel higher than the rate actually paid in recent years. This slight increase means increased earning by the railways of $1,500,000 to $3,000,000 per annum on the grain passing through the port of Buffalo.

These advances of rates are reflected in the reports of increased earnings and in the enormous increase in prices of railway stocks which has taken place recently.

Continuing the Commission says:

> It has been the understanding of late that the statutes of the United States (the anti-trust law) prohibited the advance of interstate rates by concerted action among the carriers, yet here we find an instance where in every part of this country carriers have by concerted action, without any notice to shippers, and indeed against the vehement protest of shippers, advanced their rates upon a large portion of the merchandise carried under class rates an average of one-fourth. If this can be done with respect to that portion of railway traffic, it can be done with respect to all of it; and if rates can be advanced 25%, they can be still further advanced by the same method. It can no longer be said that a general advance of freight rates is altogether a fancy, for it has become an accomplished fact. Neither can it be said that the public can escape such an advance, however unjust. Hundreds of persons have demanded relief from what has been actually done. In some instances where the shipper was great enough or the organization to which he belonged powerful enough, that relief has been voluntarily granted by the railways, but the general public and the small shipper have been compelled to make the best of it.

That this is to be a permanent state of affairs cannot be believed. The public demand that railway rates shall be subject to the control of State and National authority will certainly be heeded. The era of railway competition has lasted longer than seemed possible or probable a dozen years ago; but its end is now in sight, and in fact, so far as the great bulk of railway traffic is concerned, is already here. What form the public control of rates shall take and whether the present plan to endow the present Interstate Commission with larger powers will meet the public demands, are too large questions to consider at this time. The main point to be borne in mind is that the progress of recent railway combinations is putting a final end to competitive rates and is hastening the day when stringent public control over railway rates must be established.

For about a dozen years, an inset sheet of drawings or engravings has been a regular and we believe a much-appreciated feature of the weekly issues of Engineering News; and its absence in the present number will doubtless be noticed by many of our readers. Let us say at once that its omission does not mean any backward step in

the conduct of this journal, or any reduction in the quantity or quality of matter presented. On the contrary, the change is made partly to enable the publication of a larger amount of matter, and the pages of reading matter in the present issue will be found to number 32 instead of the usual 24.

For various reasons, the expense in presenting illustrations upon an inset sheet is considerably more than in printing them on the pages of the paper with the accompanying text; and in connection with definite plans to present a considerably larger amount of matter to our readers during the coming year by the addition of extra pages at frequent intervals, it has been deemed wise to transfer the illustrations which have hitherto appeared upon inset sheets to the pages of the paper when conditions make it advisable.

Of course, there are many cases where inset sheets are needed for the proper illustration of an article, as where it is desired to make single illustrations on a larger scale than the pages of the paper will accommodate, or where the quantity of illustrations is too great in proportion to the text to make a good appearance in the pages of the paper, or where it is desired to present a fine quality of illustration on special paper, as in the case of our annual sheet of portraits of the Presidents of engineering societies, which will appear next week. An inset supplement, therefore, will still be a frequent feature of Engineering News; but it will also be omitted from time to time; and its omission in any issue will be coincident with the presentation of more than an equivalent amount of matter in the regular pages.

Other reasons for making the change above noted are the criticisms, which have occasionally reached us, that the inset sheets are less convenient for reference than cuts in the text and are awkward in binding, liable to loss from the separate copies and to injury in the bound volumes. We recognize the justice of these criticisms; and the change above described will thus be seen to be in the interest of the readers. Were it otherwise, it would not be made.

THE DEVELOPMENT AND FUTURE POSSIBILITIES OF THE SUBMARINE BOAT

In a lecture delivered before the students of Manhattan College in New York city, and in a lengthy article in the December "North American Review," Mr. John P. Holland, the well-known inventor of the Holland submarine boat, has recently presented an interesting discussion of the development and future possibilities for both naval and commercial purposes of the submarine vessel.

The excellent showing made by the Holland boat in the naval manoeuvers off Newport last fall and the fact that the U. S. Navy now has six of these vessels under construction has aroused considerable popular interest in the efficiency of this type of vessel as a weapon in naval warfare. The proposition, however, that we shall before long find submarine boats employed as passenger carriers for short and rough sea trips like that across the English Channel makes a far greater strain on public credulity, and it will interest many to know upon what grounds Mr. Holland bases his very confident assertion that he expects some day to cross from Dover to Calais in one of a regular line of submarine passenger boats. In order to present the matter fairly we shall follow briefly Mr. Holland's reasoning as he gives it in the lecture and article referred to at the beginning of the opening paragraph.

In reviewing the past attempts at submarine navigation, Mr. Holland points out that all previous failures have in his opinion been due to two causes, which he defines as lack of longitudinal stability in the vessel, and a want of fixity in the center of gravity of the craft while descending or while returning to the surface. He states that he has established the law that the length of the boat must not exceed four or five times its breadth if longitudinal stability is to be insured. To overcome the trouble and danger arising from the displacement of the mass center in ascending and descending, he fills the water ballast tanks before starting to sink and keeps them filled during the whole operation. In the opinion of the inventor this is the great secret of his success. He has also proved to his satisfaction that the best way to descend is to plunge obliquely below the surface instead of sinking vertically on an even keel. To effect this headlong plunge he makes use of horizontal rudders. As a motive power he favors the gasoline engine when traveling on the surface, but asserts that for running under water no other motive power has been found that can be employed so well as electricity. Liquid air has been suggested, but nothing has been accomplished with it. As at present equipped with electric power, the inventor asserts that his boat will go down in any position; will stop at any desired depth, and will swing completely around in 40 seconds. The best European boats of the same type require, it is stated, 14 minutes to make a similar evolution.

Turning now to the equipment and operation of the submarine boat in warfare Mr. Holland points out that she presents the unique spectacle, when used in attack, of a weapon against which there is no defense. You cannot fight submarine vessels with other submarine vessels, since you cannot see to fight under water. A small fleet of such vessels could protect New York Harbor against an attack of the combined fleets of the world, but our shipping and the city would be at the mercy of the enemy if they had but one submarine vessel of their own manned by a fearless crew. You could not mine against her, for she would countermine; you could not close the harbor against her even with a network of torpedoes and chains stretched across the Narrows and extending from the bottom of the channel to the water surface, for from a safe distance she simply has to send a torpedo against the network to open a passage sufficient for her purposes. To attempt to pursue and attack her with your own fleet of submarine boats would be about as successful as an attempt to find a needle in a haystack. While admitting that all these are powerful factors in favor of the success of the submarine vessel as a weapon for coast defense, there are many naval men who question whether they will ever be of much value as an offensive weapon. In support of this opinion they assert that such vessels cannot live away from home and that, therefore, they will never be available for making war on a foreign country.

To prove that this assumption is faulty, Mr. Holland states that he will soon start one of his boats on a trip across the Atlantic. The route will be first to Bermuda, a distance of 676 miles, thence to Fayal, 1,880 miles, and thence to Lisbon, 940 miles, a total distance of 3,496 miles. This vessel will travel on the surface almost exclusively, and her chief motive power will be a 160-HP. gasoline engine, which will give her a speed of 9½ knots. This engine will also generate the electric power that may be needed for submerged runs and for such operations as may be conducted in the harbors at which the vessel will touch. The crew will subsist entirely on the provisions which the vessel will carry, the cooking being done by electricity, and will sleep in hammocks slung from the ceiling. While it is not expected that this voyage will be comfortable as judged from the standpoint of the regular transatlantic traveler, it will not entail any real hardship, and should it be successful it will go far to demonstrate that such vessels may be dispatched for offensive operations against a foreign foe as well as employed for coast defense at home.

With the preceding outline of the development and possibilities of the submarine boat as a military weapon, Mr. Holland enters upon a discussion of the fascinating possibilities which he considers that such craft offer in commerce. He admits at the outset that for transatlantic travel submarine boats will never be a commercial possibility. In proof of this he points out that to cross the Atlantic and to make any sort of speed a submarine boat the size of one of the large transatlantic liners would have to carry electric storage batteries aggregating in weight about six times the weight of the vessel herself. The impossibility of securing power, therefore, stands as an absolute bar to commercial traffic across the ocean under water, even assuming that the confinement, lack of sunshine and fresh air did not prove to be insuperable objections. For short trips, however, Mr. Holland considers that the submarine boat offers commercial advantages that will render it a dangerous rival to the surface-sailing vessel if, indeed, it does not drive it out of the competition in particular waters. As a notable example he mentions the passage across the English Channel in which seasickness attacks the most hardened ocean traveler, and where storms and fogs cause collisions and discomforts, which deter thousands of persons every year from making the voyage. In a submarine boat free from odors and disturbing motion to cause seasickness and entirely free from danger of collision, storms and fogs will have no existence for the traveler and the most timid and delicate of stomach can make the voyage without discomfort. It is interesting to note that Mr. Holland's idea for a vessel for this traffic is a boat not over 160 ft. to 200 ft. in length, which will be kept true to her course by means of cables running from shore to shore, on which will run an automatic steering gear attached to the vessel.

In regard to the role which Mr. Holland thinks that the submarine boat is destined to play in scientific research, the following extracts are fully explanatory:

> With her aid the bottom of the ocean will be safely explored at comparatively great depths. Just how far down we shall be able to go in her no one at this time knows. Whatever the depth, it is certain to be much greater than any explorers have heretofore been able to reach in person, and the scientists are certain to take full advantages of her possibilities. In certain submarine pursuits, such as wrecking, pearl and sponge fishing, etc., a complete revolution will be wrought. Millions of dollars now lost to the world in submerged wrecks will be recovered, and the work of raising sunken ships will be a matter of days instead of months, with the submarine's aid. The surveying of harbors and shoals and obstructions to navigation will be reduced to an exact science. Where now such surveys can be made only semi-occasionally, a perfect system of submarine control will be maintained.

Mr. Holland is careful to state that much missionary work will probably still have to be done before people can be taught to take full advantage of the possibilities of submarine navigation which have been outlined, but he thinks that the time is in sight when the prejudice against going through instead of over the water will have disappeared. In conclusion Mr. Holland draws some comparisons between the safety of submarine navigation and the present means of transportation by both water and land. He points out that there have been submarine boats for more than 300 years, and that in all that time only one life has been lost in a boat running beneath the water, and asks what other system of transportation can show such a clear bill. He then continues as follows:

> Last year 7,123 persons were killed on the railroads of America alone. In the city of Brooklyn alone over 300 people have lost their lives since the first trolley spun merrily along the streets of that city. It is no uncommon thing for a whole shipload to go down into the depths. When in contrast with these experiences, it is remembered that only one life has been lost in a submerged boat, it must be agreed that the objection to submarine travel is a superstition

In the preceding abstract we have endeavored to present in a perfectly fair manner the discussion of submarine vessels by Mr. Holland in the lecture and article referred to in the opening paragraph. With the principles which he gives as the basis of successful submarine boat design, no question can be very well raised. As carried out by Mr. Holland, they have given a submarine vessel whose success is admittedly greater than that attained by any other inventor of this type of vessel. Regarding the efficiency of the submarine boat in defensive warfare, Mr. Holland's statements can also be accepted without much reservation, although it may be questioned whether the certainty and safety of operation which he assumes has yet been demonstrated beyond serious doubt. In offensive warfare against a foreign coast the capacity of the submarine boat to cross the ocean and conduct operations without other aid remains to be proven. As Mr. Holland proposes to present such proof at an early date, we can very well leave this point for the future to settle. Turning now to the very sanguine prophesy which Mr. Holland makes for the utility of the submarine vessel as a passenger carrier, and as a tool for reaping scientific and material wealth from the sea bottom, we find considerable opportunity for criticism.

As dated above, Mr. Holland believes that the fear of storms and collision, and the dread of seasickness, will cause passengers to choose the

submarine vessel in preference to ordinary steamers in such voyages as that across the English Channel. These may be far more important influences than we imagine, but they certainly seem a rather slender argument upon which to base so radical a claim. Laying aside for the moment the prejudice which people may naturally feel against trusting themselves below water in a submarine vessel, it is clear that the safety of such craft compared with other means of transport is far from proved. To draw general comparisons between the one recorded death (not to go behind Mr. Holland's figures) due to submarine navigation, and the 7,123 deaths resulting from railway accidents in the United States last year, conveys a false impression. By the same token, Mr. Holland might have quite as well claimed that submarine navigation was safer than eating fish, for it is quite certain that many persons have choaked to death on fish bones during the last 300 years. While 7,123 persons were killed in railway accidents in 1898, only 239 of the number were pasengers out of a total of 523,176,508 passengers carried, and only 2,210 were employees out of 928,924 men employed on railways. When the submarine boat lines, of which Mr. Holland dreams, can show a pay roll of 928,924 names and a passenger list of 523,176,508 persons, with no more than 7,123 deaths per annum, they will be proved to be as safe as railway transportation, but that time is not yet in sight.

Turning now to the fascinating speculation regarding the reaping of sunken treasure from the ocean bottom, a little consideration shows that these possibilities are very remote. The submarine boat may, perhaps, carry wealth hunters to these rich fields, but some means will then have to be devised to gather the harvest. Men in diving suits will have to leave the vessel to do this work, and these men can work at no greater depth by starting from a submarine boat than they could if they started from the surface. Jules Verne provided the crew of the "Nautilus" with compressed air tanks and electric head lights to enable them to promenade the sea bottom in fiction, but these things have not yet been accomplished in fact. Indeed, notwithstanding the labors of all our bright inventors in this interesting field, the ability of divers to live and work under water is at the present time exceedingly limited. This is a detail which we should not despair of seeing improved, but it cannot be assumed as granted in speculating upon the possibilities of the submarine boat for pearl and sponge fisheries or gathering sunken treasures, or for raising sunken vessels and making hydrographic surveys.

So far we have credited the submarine vessel with perfect dirigibility and control, but it is evident that these are questions which have not yet been placed beyond doubt. It may be pointed out that Mr. Holland tacitly admits uncertainty of steering capacity in his proposition to stretch cables across the English Channel to keep the vessels of his speculative submarine boat line true to their course. The fact will suggest itself to the engineer that there will be some practical details to be worked out in this plan which do not present an obvious solution at first sight at least. The more general inference to be drawn from the proposition is, however, that the submarine boat is not such an independent self-sufficient contrivance as some of the claims made for her would seem to indicate. It would be possible to go much further with these and similar criticisms, but our readers will easily be able to do it for themselves.

In conclusion, we feel that it is only just to credit Mr. Holland with remarkable perseverance and inventive ability in his work of placing the submarine boat on the practical footing which it now occupies. He has certainly done more than any one else working in the same field, and has really given to the world a submarine craft of remarkable efficiency, and one which we may expect to see vastly improved in the future. Our only contention is that neither engineering invention nor Mr. Holland himself is benefited by indulging in fanciful prophesies and attempting to bolster them up with statements so open to criticism as some of those which we have discussed above.

LETTERS TO THE EDITOR.

Map vs. Field Location of Railways.

Sir: Referring to the letters on railway location which have recently appeared in Engineering News, I fully agree with the remark attributed by you to the late A. M. Wellington concerning the excellent location of some of the eastern railways; as exemplified, for instance, in the crossing of the Allegheny Mountains by the Pennsylvania and Baltimore & Ohio Railroads.

While these are notable examples of good railway locations, there are to be found everywhere many instances of bad, and we may say very bad locations. I think it will be found upon examination that a large percentage of bad locations can be attributed to the method employed in making them: a method very much in vogue at one time, and consisting of making the location in the field, without the intervention of maps, the location following closely the variations of the ground and generally resulting in a great excess of curvature.

The writer believes that railways located from maps, or what is generally known as paper location, show a much better alinement. Respectfully.

Emile Low, M. Am. Soc. C. E.

Buffalo, N. Y., Dec. 29, 1900.

The Measurement of Railway Grades.

Sir: In your issue of Dec. 13 Mr. H. P. Gillette offers a criticism of the writer's definition of a 100% grade which appears to miss the point. There is no controversy about the universal definition given by him in the terms chosen, viz.: ratio of rise to horizontal distance. But it should be pointed out that the selection of those terms is not necessary; it is simply convenient. A more rational basis would be the ratio of rise to grade length for the latter would also express actual grade resistance.

Wellington's rule was cited as theoretically and actually correct for all values of grade resistance on the last named basis. He notes the error in its application to grades as actually laid out. In the latter case, carrying the calculuation to a logical end would give practically an infinite grade of infinite resistance, which is absurd. The point in the original article is grade rates on the basis of grade resistance.

Now the writer will say something else heterodox, viz.: a railway line should be measured parallel to its grade. This would give exact quantities in graduation and track material and would make the grade a direct expression of grade resistance. But the general use of such a method is not advisable. Among other objections there would be the difficulty of correct application on original location in broken country. Within the limits of ordinary practice, the present method is practically exact. In the case of the heavy grades forming the original subject of this discussion, however, the horizontal measurement would introduce errors of 7 or 8% and, as there is one tunnel of considerable length, the method of measurement was of vital importance to the contractor. J. L. Campbell.

Clifton, Arizona, Dec. 20, 1900.

The Shrinkage of Earthwork.

Sir: I have watched with a great deal of interest the letters in your columns in regard to shrinkage of embankments, and I fully agree with Mr. H. P. Gillette that 3% is much nearer correct that Prof. Johnson's 16⅔% or even Mr. Tuttan's 5% or 9%. I have given this subject very careful attention during the last 14 years, and have been in actual charge of railroad work from the Mississippi River to Virginia. I find the following to be an average shrinkage:

Embankments made of coarse, clean sand, gravel and small bowlders mixed, put up with wheel scrapers, about 1%. Embankments made of clay, loam and any ordinary earth, on good foundation, from 2% to 3%. Colico, clay, kaoline and kindred materials put up with wheel scrapers will shrink about 5%; put up with carts or wagons, an average of about 8%.

During 1890 and 1891 I was in charge of 52 miles of construction between Menlo, Ga., and Gadsden, Ala., and by actual levels run from three to six months after this work had been completed I found that the wheel-scraper work had settled from less than 1% to 3%. Embankments built with carts, cars and wagons had settled from 4% to 10%, according to the class of material. Wheelbarrow embankments shrink according to material used and the skill of the man building from 15% to 25%.

A great many engineers confound spreading and "sumpage" (i. e. settling into the ground where the foundation is bad), with shrinkage. This should be carefully avoided, as contractors are supposed to be paid for the amount of material actually moved. My opinion is that all work should be paid for by excavation measurement, then the engineer in charge can put on the amount of shrinkage he sees fit, or may think will be required, without injury to any one.

Woolsey Finnel, City Engineer.

Box 97, Tuscaloosa, Ala., Dec. 25, 1900.

Analysis of Pressures on the Foundation Footing sfor Walls of Buildings.

Sir: I was called upon, recently, to give expert testimony with regard to the distribution of pressure upon the subsoil, transmitted through the medium of a building foundation wall of faulty construction. The foundation was 3 ft. wide at the bottom, and 2 ft. wide at the top, with a batter of 1 ft. on the inside. The brick wall resting on this footing was 16 ins. thick, placed with its outside face 1 in. from the outside of the foundation. All of the text books at hand were consulted, but no mathematical analysis of such a problem could be found. I therefore evolved the following formulæ, upon the assumption (1) that the pressure would vary uniformly from one side of the base to the other, and, (2) that the load coming down the 16-in. wall may be regarded as concentrated at the center of the base of this wall. I submit the analysis to you, believing that it may be of some interest, and with the request that you point out to me any literature that you know of upon the subject.

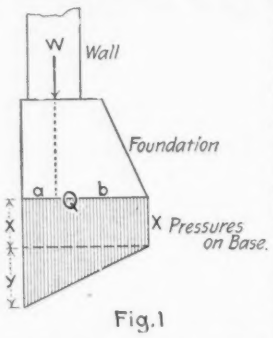


Fig. 1.

The base is divided by the line of application of W (the load) into segments a and b, Fig. 1. The pressure transmitted to the soil is represented by the trapezoid having x and x + y as bases. It is evident that the total pressure on both sides of W is equal to W. Also the sum of the moments of all the forces about Q is equal to 0; hence the following two equations:

$$\frac{b^2 x}{2} + \frac{b^3 y}{6(a+b)} - \frac{a^2 x}{2} - \frac{a^2 y}{3} + \frac{a^2 b y}{3(a+b)} - \frac{b a^2 y}{2(a+b)} = 0. \quad (1)$$

$$2x + y = \frac{2W}{a+b}. \quad (2)$$

Eliminating y we have

$$x = 2W \frac{2a^3 + 3a^2 b - b^3}{(a+b)^4};$$

$$y = \frac{2W}{a+b} - 2x.$$

Example.—Let a = 1 and b = 2, then

$$x = 2W \frac{2 + 6 - 8}{81} = 0;$$

$$y = \frac{2W}{3} - 0 = \frac{2}{3} W,$$

which result is to be expected, since the center of gravity of a triangle is at a distance of one-third of the altitude from the base.

Now, let a = 1 and b = 9, then

$$x = -.14\ W;$$

$$y = +.48\ W, \text{ and } y + x = +.34\ W,$$

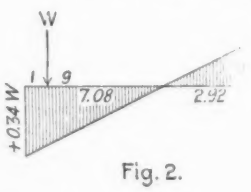


Fig. 2.

and the pressure diagram would be as shown in Fig. 2. The algebraic sum of these two areas is equal to W. The sum of the moments about the point of application of W is equal to 0. We have then a total positive pressure of 0.316 W to the left of the load, and a total positive pressure of 0.888 W and a negative pressure of 0.204 W to the right of the load:

$$0.316\ W + 0.888\ W - 0.204\ W = W.$$

Yours respectfully, E. A. Kemmler, Assistant City Engineer.

Columbus, O., Dec. 15 1900.

(In our issue of Oct. 19, 1899, we published a formula for computing the strength of concrete footings for columns submitted by Mr. W. C. Lyon, of the Government Architects' office, at Washington, D. C., and in our issue of March 8, 1900, we presented an abstract of an article on the computation of concrete footings for walls and columns by Mr. Geo. H. Blagrove, of London, England.—Ed.)

Calculating the Volume of Irrigation Canals.

Sir: I have been very much interested in the article by Mr. Gillette, "The Rapid Calculation of Earthwork," which induces me to present a method of calculation and correction I have used for many years in the construction of irrigating canals, where usually no center reading is taken in cross-sectioning. This method may be of interest to some of your readers. The example given is for stations of 100 ft. length and side slopes of 1 to 1, for other dis-

tances and slopes, there would be a proportional correction.

Let

a = lower cut at first station;
a′ = lower cut at second station;
b = upper cut at first station;
b′ = upper cut at second station;
A = area at first station;
A′ = area at second station;
B = base or width of cut or fill.

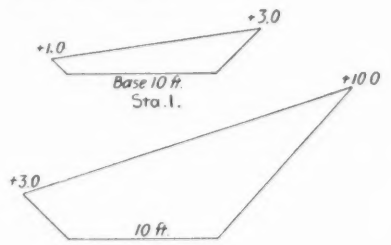
Then

$$A = (a + b) \times \frac{B}{2} + (a \times b);$$

$$A' = (a' + b') \times \frac{B}{2} + (a' \times b').$$

$$\text{Volume by end areas} = \frac{(A + A')\ 100}{2 \times 27}.$$

Correction to be subtracted $(a' - a) \times (b' - b) \times 0.617$ (0.617 for slopes of 1 to 1).



$3 + 1 \times 5 = 20$, $3 \times 1 = 3$, Area..... 23

$3 + 10 \times 5 = 65$, $3 \times 10 = 30$, Area..... 95

Volume by end areas, 218.5 cu. yds. Prismoidal correction to be subtracted, $2 \times 7 \times 0.617 = 8.6$ cu. yds; $218.5 - 8.6 = 209.9$ cu. yds. I believe that a rigorous mathematical examination of the above will prove it to be not only approximate, but correct. Yours, etc.,

F. T. Lewis.

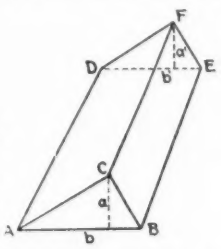
La Junta, Colo., Dec. 27, 1900.

A Prismoidal Correction Formula.

Sir: I have read with interest Mr. H. P. Gillette's article in your issue of Dec. 13, in which he gives the derivation of an approximate formula for the correction of volumes computed by the "mean end area formula."

Another formula, with which doubtless many of your readers are familiar, giving exact results, is

$$C = \frac{L}{324}\ (a - a')\ (b - b').$$



The derivation of this formula is as follows: Let A B C D E F be a solid with triangular parallel ends and one plane side, A D E B. (The sides A D F C and B E F C may be either warped or plane surfaces.)

V = exact volume in cubic yards, as found by the prismoidal formula;
V′ = approximate volume in cubic yards, as found by the mean end area formula;
C = prismoidal correction in cubic yards = V′ − V;
b = base, and a = altitude of end A B C, in feet;
b′ = base, and a′ = altitude of end D E F, in feet;
L = perpendicular distance between ends, in feet.

It may be easily shown that

$$V = \frac{L}{12 \times 27}\ (2\,a\,b + 2\,a'\,b' + a\,b' + a'\,b),$$

and

$$V' = \frac{L}{12 \times 27}\ (3\,a\,b + 3\,a'\,b').$$

Then

$$C = V' - V = \frac{L}{324}\ (a\,b + a'\,b' - a\,b' - a'\,b);$$

$$C = \frac{L}{324}\ (a - a')\ \ (b - b')$$

When three-level cross-sections are used the correction for the entire solid takes the form

$$C = \frac{L}{324}\ (c - c')\ (D - D'),$$

in which

c = center height; and
D = distance between slope stakes at one section;
c′ and D′ = corresponding distances at the next section.

This form of correction has the advantage of being entirely independent of the method used in obtaining the volume by the mean ends formula, whether by table, diagram, or by the actual computation of the end areas. The value of C may be readily computed by the use of the slide rule, or taken from tables such as Crandall's or Allen's, or from a diagram. A full discussion of the prismoidal correction is given in Allen's "Railroad Curves and Earthwork." Yours truly, F. E. Foss.

State College, Pa., Dec. 24, 1900.

Stream Pollution By Alum in the Wash Water from Mechanical Filters.

Sir: Is not the wash water discharged from mechanical filters, containing the apparently insoluble sulphate of alumina, a serious source of pollution, and does it not unfit the water for cattle and fish, and the users below where it is dumped into the stream? Most of our streams are not large and they cannot, in my opinion, stand large and continuous doses of sulphate of alumina.

To illustrate, take a water-works, pumping 15,000,000 gallons a day, where the conditions of the water is such as to require the use of 1½ grains of sulphate of alumina to the gallon. This would be a total of 22,500,000 grains per day, or 3,214 lbs.; or a car load of 32,140 lbs. every ten days, or 1,173,110 lbs. per annum. The cost at 1¼ cts. per lb. would be $14,664.

Take four plants pumping 15,000,000 gallons each per day, aggregating 60,000,000 gallons, and using on an average 1½ grains of alum to the gallon, and they will dump into the stream 12,856 lbs. per day, or 128,560 lbs. every ten days, or 4,692,440 lbs. in a year, at a cost of $58,655 per annum. It seems to me that a stream receiving so much pollution would have to be very large, otherwise this whitish flocculent sulphate of alumina must discolor and otherwise render unfit for other uses the water of the stream. Should it be determined by suit that the wash water of mechanical filters using alum as a coagulant is pollution, can a remedy be applied and what would be the method and cost?

Looking at the question from a financial and sanitary standpoint, it seems to me that it would be better to use a system of filtration that does not require the use of a coagulant, which is pollution when thrown into the stream. The amount of money paid for the alum had better be spent for labor in cleaning filter beds, thereby supporting laborers.

A water-works polluting a stream cannot reasonably ask others to stop polluting it. It is claimed by some experts that certain waters cannot be purified without the use of a coagulant because of the fine silt in the water during certain periods. Nature uses no coagulant and it seems to me that they should study nature's methods and adopt them for the purification of water.

Stream pollution of every kind should be stopped by all means. It is a menace to life and health and interferes with the enjoyment of the people. It detracts from the value of the land along streams and the beauty of the landscape, which is a valuable consideration. Streams should be kept pure for the cattle, for the water fowl, birds and fishes, and beyond all the water purveyor who cannot in all reason be expected to supply wholesome water from a polluted source. For these reasons the water purveyor should be the last to offend by polluting with a mineral salt the stream whence his supply and that of his neighbor is drawn.

I quote the following from Gould on "Water" (p. 430): "It has been held by the courts that the letting off of water made noxious by the precipitation of minerals, or dye wares, or liquors, or madder, indigo, or potash, or sulphuric or muriatic acid, or vitriol, whereby the boilers and machinery of a lower proprietor are corroded; discharging heated water into a stream injuriously, or sewage; or rendering the water unfit for domestic, culinary or mining purposes, or for cattle to drink of, or fish to live in, or for manufacturing purposes, is actionable."

F. A. W. Davis, Vice-Pres. Indianapolis Water Co.

Indianapolis, Ind., Dec. 7, 1900.

(The question raised by our correspondent is an interesting one, and feeling that many of our readers would like to know how it is regarded by the makers of mechanical filters we submitted a proof of the letter to the New York Continental Jewell Filtration Co. and append its reply as follows:—Ed.)

Sir: With reference to the very interesting questions raised by Mr. F. A. W. Davis, Vice-President of the Indianapolis Water Co., in a communication to Engineering News, dated Dec. 7, 1900, proof of which you have kindly allowed us to examine, we should like to call your attention to the following points:

Sulphate of alumina is not present in the wash water from mechanical filters, unless contained in the filtered water used for washing the filters. This is a condition which is generally recognized to be inexcusable and inadmissible. Hydrate of alumina, which is the product resulting from the decomposition of sulphate of alumina by lime, and which is the active coagulating agent, is, however, present in the wash water. This is the compound which holds the suspended matter together and which is removed together with the suspended matter by the process of purification, consisting of subsidence and filtration, which is known as the American system. In cleaning the settling basins and filters, these materials, in the form of a thick sludge, are removed and pass normally into the sewerage system and thence either to the sewage purification works or to some running stream. It is apparently the hydrate of alumina which may thus be discharged into the various streams which has caused Mr. Davis to become apprehensive of serious pollution, though he has unfortunately confused the sulphate of alumina with the hydrate.

As the hydrate of alumina is simply the combination of water with the oxide, it is probably the metal in this compound to which Mr. Davis attributes possible polluting characteristics, considered from the hygienic point of view, though he evidently in the third paragraph of his letter fears trouble owing to the injury of the appearance of the stream by the flocculent hydrate of alumina.

Hydrate of alumina, or an equivalent coagulant, is required for the successful filtration of many surface waters, in order to aggregate those fine clay particles, which would otherwise pass through a filtering medium, which was sufficiently high in quantitative efficiency to be available from an economic standpoint for purification of municipal supplies. This is undoubtedly known to Mr. Davis, but he has evidently overlooked the fact that the clay, which it is necessary to remove, contains normally about 10% of aluminum. With an annual average of 350 parts per million of suspended matter, it was estimated at Louisville (Louisville Report, page 430) that 1.75 grains of sulphate of alumina per gallon, containing 9.87% aluminum would be required. Making a reasonable allowance for other forms of suspended matter which would not contain aluminum, it seems probable that there would be about 30 parts per million suspended aluminum in the Ohio River water, to which would be added 2.95 parts per million or slightly less than 10%. As, so far as we can ascertain, the aluminum as hydrate is no more noxious than the compound combination of aluminum and silica, which forms the bulk of the clay, it seems difficult to comprehend how any objection could be raised to the restoration of the aluminum to the stream when increased by only 10%, the addition being in the form of hydrate.

This does not take into consideration, in any way, the amount of dilution which normally occurs or the relation of the aluminum added, to that which is present in the entire stream. On this basis at Louisville, with a plant of 25,000,000 gallons capacity, the amount of aluminum added would be on an average sixteen thousandths of one per cent. (0.016%) of the aluminum present in the stream. At low water, the amount added would be about twenty-eight thousandths of one per cent. (0.028%), and at high water about six millionths of one per cent. (0.00000.6%.) We can hardly comprehend how such conditions can be considered seriously detrimental, when it is borne in mind that the normal fluctuation of the amount of aluminum present in a stream of this kind is several thousand-fold.*

With reference to the relative desirability of utilizing some method of purification which does not require a coagulant, we do not desire to take exception to the attitude held by Mr. Davis, but we beg to call the gentleman's attention to the fact that Louisville, Cincinnati and Washington have spent large sums of money, thus far unsuccessfully, in the endeavor to find methods of purification which would avoid the use of coagulant; that the city of Pittsburg in proceeding with the designs of English filters does so in the face of clear evidence that at times the plant will not be able to deliver a clear water; and that the plant of the city of Albany during the freshet of last spring delivered an effluent which in appearance was anything but satisfactory.

Mr. Davis has further overlooked the fact that the effluent from sewage disposal works, using chemical precipitation, normally contains a large amount of the coagulating chemicals, to which, so far as we can ascertain, no ill effects have been attributed in the numerous plants in operation. Further, the relation of the amount of sludge in the water purification works to the amount of sewage in the city has evidently not been considered and the fact that this sludge, containing, as it does, hydrate of alumina or equivalent coagulant, would be an aid rather than a detriment in the operation of any municipal sewage-disposal plant, has evidently been overlooked.

Finally, it would appear that the amount of aluminum hydrate was very insignificant in comparison with the suspended matter normally present in the stream and that its action would, if anything, tend to clarify rather than pollute the stream. Yours very respectfully,

New York Continental Jewell Filtration Co.,
Chas. L. Parmelee, Consulting Expert.

Mills Building, New York city, Dec. 26, 1900.

Notes and Queries.

In reference to the description of the North German Lloyd piers at Hoboken, N. J., which was printed in our issue of Jan. 3, 1901, Mr. W. F. Whittemore, the engineer in charge, writes:

You have left out one of the important features of the plan, viz.: The construction and arrangement of the roof

*Aluminum oxide, or as it is frequently called "alumina," is a combination of oxygen and aluminum. It has the chemical formula, $al_2\ o_3$ and contains 53.03% of aluminum. Aluminum hydrate, or hydrate of alumina, is the combination of the oxide with water. It has the chemical formula, $al_2\ (ob)_3$ and contains 51.52% of aluminum.

of the bulkhead building as a promenade for the accommodation of the friends of passengers traveling by this line, who may wish to witness the arrival and departure of the ships. The elevators and inside and outside stairways connect with the roof. The plans were first prepared by me and then submitted to the gentlemen mentioned in your opening paragraph for their criticism or suggestions along the lines of their well-known experience. The first street west of the property is River St. and not Water St., as stated. The concrete on the surface of the pier and the oak along its sides are intended primarily for fire protection. In addition to the fire appliances mentioned, there will be a complete equipment of large and powerful fire pumps, one of which will be ready for immediate operation at all times.

STEEL AND CONCRETE TIES have been tried experimentally on the Chicago Terminal Division of the Pennsylvania Lines West of Pittsburg. There were 30 of these ties laid in the westbound main track of the Pittsburg, Fort Wayne & Chicago Ry., just north of Harrison St., on a curve of 6° 30'. The rails were of the 85-lb. Pennsylvania R. R. section, and the ballast was of broken stone. The track runs directly to the Union Station and all westbound trains of the Chicago, Burlington & Quincy R. R., Chicago & Alton Ry., and Pittsburg, Fort Wayne & Chicago Ry. pass over it. The speed is slow, about 15 miles an hour. The ties were laid in June, 1899, and were in service until April, 1900, when they were removed. At first they were inspected daily, and afterwards twice a week. Mr. Robert Ferriday, Assistant Engineer, informs us that at the end of 15 days, two of the ties were found to be in a shattered condition, the concrete having separated from the iron. These were replaced with new ones, but no other ties of the same kind were put in after these had been removed. The ties were examined Dec. 9, 1899, and 10 of them were found to be cracked. Two of them were badly cracked, owing probably to poor mixing and packing of the concrete. The track had not been relined or surfaced since the ties were put in. The ties were 7 ft. 4 ins. long on the bottom, 8½ ins. deep under the rails, 12 ins. deep along the center of the tie, about 10 ins. wide under the rail and 6 ins. wide under the center. They were very short and it was considered doubtful if they would make a good track for high speeds. The ties were removed from the track on account of the failure of the device locking the rail to the tie. It is possible that in future experiments with the tie more satisfactory results will be obtained with the concrete itself. The cost of these ties, which were the first ones ever made, was about $8 each. This was due to making the patterns, changing the patterns and other extra work. It is believed that the cost will be less than $1 each, if made in any quantity. The tie was patented by Mr. C. C. Harrell, of Chicago, and was called the "Composite steel and concrete railway cross-tie." The design was afterwards taken up and modified by Mr. J. J. Harrell, of Wilmington, Del. The design is a combination of two channel bars, 7 ft. long, forming the top and bottom of the tie, separated by distance pieces, and braced under the rail seats by vertical and inclined struts between the bars. A short piece of channel iron forms the rail seat, and through this pass the anchor bolts, the heads of which are under the lower channel bar. The whole structure is embedded in concrete with the exception of the rail seat. The rail rests on a shim or packing plate and is secured by bolted clamps filling the rail base and the edge of the channel. The complete tie is 7 ft. 8 ins. long, 8 ins. thick, 5 ins. wide at top and 8 ins. at the bottom, the weight being about 300 lbs. It was found that with a single rod or bar through the concrete, the deflection caused the disintegration of the concrete, and the truss design above noted was adopted in its stead.

THE COMMERCE OF THE GREAT LAKES for 1900 is reported upon by the U. S. Bureau of Statistics. As to the relative importance of the several lake ports, as handlers of water-borne commerce, Chicago leads as a receiving port for hard coal, 678,094 tons having been unloaded at her docks; Milwaukee comes next with 476,502 tons, and then come South Chicago and Duluth. About two-thirds of this hard coal came from Buffalo, a total of 1,208,727 tons having been shipped from that port; Erie, Pa., the only other coal-shipping port of importance, sent out 488,758 tons up to the close of navigation on Dec. 1. Of soft coal, West Superior received 1,270,183 tons; Milwaukee, 726,044 tons, and Duluth is a close third. Up to Dec. 1 lake steamers carried 1,177,850 tons of flour; Duluth alone shipping 331,449 tons, and West Superior 322,590 tons. Of the total shipment of flour 930,793 tons were unloaded at Buffalo. As showing the extent to which the lake steamers compete with the railways as carriers, the report shows that the ports of Chicago, Duluth, Milwaukee, South Chicago and West Superior, the principal grain-shipping ports, shipped the following aggregates: Wheat, 44,075,831 bushels; corn, 65,241,543 bushels; oats, 23,064,741 bushels; barley, 6,939,530 bushels. Buffalo unloads very nearly all of this grain. In the shipment of iron ore to Dec. 1, Two Harbors seems to hold the year's record, with 3,652,256 tons; Duluth shipped 3,570,787 tons and Escanaba 2,876,298 tons. Of this Ashtabula unloaded 3,473,676 tons; Cleveland, 3,036,717 tons; Conneaut, 2,388,293 tons, and South Chicago, 2,022,292 tons. Of lumber shipments, Duluth alone sent out 359,264 thousand feet, and almost half of the total lumber shipped came to either Chicago or Cleveland, the former city receiving 538,246 thousand and the latter port 430,320 thousand feet. Under the head of unclassed freight, Buffalo shipped 647,645 tons and Chicago 402,889 tons, and these two cities received 652,872 and 793,909 tons of this freight respectively. A total of 7,099 vessels entered Chicago harbor in the year, with 3,684 vessel entries at Buffalo, 3,343 at Cleveland and 3,057 at Milwaukee.

THE NEW YORK DEPARTMENT OF DOCKS and Ferries is about commencing the improvement of the North River water front between Bloomfield and 22d Sts. This work involves the building of 3,000 lin. ft. of granite sea wall and the construction of ten piers. Each pier will be 800 ft. long by 125 ft. wide, with slips between about 250 ft. wide. These piers are to be absolutely fireproof, of concrete and iron construction, with wood used only below mean tide. The marginal street in the rear of these docks will be 250 ft. wide; and the completion of this project will result in a continuous stretch of new docks, etc., from Cortlandt to 34th St., on the North River.

THE NORTHWESTERN STEAMSHIP CO., of Chicago, has launched the first of four steamships now being built to carry Western products to Europe. These four vessels will cost $1,000,000, will carry 3,200 tons each, and have a speed of 15 knots. They will go through the Lakes, and St. Lawrence canals to Montreal and thence to the ocean; and as the Welland Canal only permits 14-ft. draft, they may either be lightered at Port Colburn, or the loading may be completed at Montreal. Their ocean draft is 20 ft. fully loaded. The leader in this enterprise is Mr. Charles Counselman, of Chicago.

THE WORLD'S SHIPBUILDING IN 1900, according to the reports compiled by the various interests, amounted to the following output for the chief shipbuilding nations:

	Vessels.	Tons.
The United Kingdom	1,237	1,639,950
Germany	247	252,533
United States	87	179,138
France	40	73,310
Russia	11	47,123
Holland	101	35,637
Italy	10	34,834
Norway	38	27,166
Japan	41	23,784
Austria	8	21,776

The grand totals for all nations are 1,925 vessels, aggregating 2,369,861 tons. Last year's total tonnage was 2,445,232 tons, and this decrease is mainly in the lessened production of the United Kingdom, which was 1,728,650 tons in 1899. The United States also shows a slight decrease, from 182,528 tons in 1899; as does Germany, from 258,277 tons.

THE PROPOSED PORT OF ROSARIO, Argentine Republic, has been reported upon by Mr. E. L. Corthell, M. Am. Soc. C. E., Consulting Engineer to the government. He approves the general plans for the port and he commends the careful and extended study of the hydraulics of the Parana River made by the authorities, and recommends these to engineers as forming one of the most serious and most satisfactory studies in existence relating to the hydraulics of great rivers. He also approves of the commercial and financial features of the project as sufficient and convincing, both as to revolutionizing the commerce and industry of the Republic by the establishment of this port, and as to the freedom from risk of loss in carrying out this project.

A CALIFORNIA IRRIGATION COMMISSION was proposed at the recent meeting of the California Water & Forest Association. The plan was put forward in the shape of some resolutions, offered by Mr. Wm. E. Smythe and adopted by the association. The commission would be entirely unofficial in character. The resolutions also provided for the formulation of a code of irrigation laws by the commission, to be published by the association, prior to its next annual meeting. The newly elected officers of the association are: President, Wm. Thomas; Secretary, F. C. Friedlander; Treasurer, F. W. Dohrman. All these men reside in San Francisco.

PROJECTED PUBLIC WORKS IN HUNGARY are reported by the British Embassy to Vienna, as follows: A commercial harbor at Budapest, where there is now but a single wharf and one grain elevator to handle a rapidly-increasing river traffic that in grain alone amounted in 1897 to 10,119,000 meter-centners. The new harbor would at first consist of three basins, 10 ft. deep at the lowest water mark, and the quays would be built of stone and wide enough to hold warehouses, grain elevators and traveling cranes. In connection with the harbor a large freight and coaling station is also projected and a large area of land is reserved for factory sites. It is further proposed to use the upper part of the Savoksor branch of the Danube as a basin for handling the large quantity of building material coming to Budapest by river, the basin to have a separate entrance lock. The Danube-Theiss barge canal, discussed, would have for its principal object the handling of the products of the large grain-growing district of the Alfalde, on the River Theiss. The main branch of the canal would connect Budapest with Csongrad and be about 93 miles long, with a branch about 42 miles long from Felegyhaza to Szegedin. The distance from Csongrad to Budapest by the natural waterway is 440 miles, instead of 93 by the projected canal. The proposed Danube-Save Canal would run from Vukovar, on the Danube, to Saurac, on the Save, a distance of 35.6 miles; the distance by natural waterways is now 297 miles. It would also be a barge canal. Plans for all these are now being made by the Hungarian government.

RAIN-MAKING EXPERIMENTS were advocated by enthusiasts in different parts of the country last year, and the experiments made by the Chicago, Rock Island & Pacific Ry. some years ago, were put forward as a support of the claims made. These experiments were fully described in Engineering News, Feb. 14, 1895. An article in the "Monthly Weather Review" some months ago pointed out that while there were numerous cases in which the operations were followed by rain, yet those who studied the daily weather map could see that these rains accorded with the general weather conditions, and were not the result of the experiments. In reply to an enquiry, Mr. H. A. Parker, First Vice-President and General Manager of the C., R. I. & P. Ry., informs us that the experiments were dropped some years ago, and that the officers are of opinion that they should never have been commenced.

BOOK REVIEWS.

AIR, WATER AND FOOD FROM A SANITARY STANDPOINT.—By Ellen H. Richards and Alpheus G. Woodman, Instructors in Sanitary Chemistry, Massachusetts Institute of Technology. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 6 × 9 ins.; pp. 226; tables and illustrations. $2.

This is a remarkably good elementary discussion of the subjects named, combined with descriptions of laboratory methods for analyzing air, water and food. Although the book is relatively small it contains many valuable and highly practicable suggestions. There are a number of useful tables of relative food values and laboratory information. Finally, there is a fairly extended bibliography of the subjects treated. While the book appears to have been designed primarily for students it would be well worth the price to many engineers and non-professional readers as well.

STREET PAVEMENTS AND PAVING MATERIALS.—A manual of city pavements; the methods and materials of their construction. For the use of students, engineers and city officials. By Geo. W. Tillson, M. Am. Soc. C. E., Principal Assistant Engineer, Department of Highways, Brooklyn, N. Y. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 6 × 9 ins.; pp. 532; 73 tables and 60 figures in the text. $4.

Within the past few years a large amount of work has been done in the way of putting street paving on a scientific basis. Among the various municipal engineers who have taken part in this work the author of this volume has been conspicuous. It is, therefore, a pleasure to welcome a book on city pavements from his pen, particularly as the leading treatise on the subject was written a number of years ago and has not been subjected to a thorough revision. The earlier book, it is hardly necessary to say, is Byrne's "Highway Construction," a volume having a wider scope than Mr. Tillson's new book, which is devoted almost wholly to city work. The present volumne opens with an interesting historical chapter, after which the different paving materials are described in some detail, both as products of nature and of industrial art. Thus, there are chapters on stone, asphalt, brick clay and their manufacture into paving brick, and one on cement, cement mortar and concrete. The aim of these chapters is to give such information as is necessary to select the best paving material and prepare it for use on the street, with the exception that the final preparation of asphalt is described in the chapter on "Asphalt Pavements." After having traversed the ground already indicated, the author presents a most admirable chapter on "The Theory of Pavements," which includes a discussion of the essential qualities of pavements, with the relative importance of each quality, which is finally expressed in percentages, as 15% for cheapness, 21% for durability. These percentages established, the various paving materials are discussed and their values given under each heading, and finally a table is presented, including each paving material as rated in detail and total. In this table the best granite has 69 points; asphalt, 76; brick, 67; belgian block, 52; macadam, 45; cobblestone, 44. The application of the table to special streets is interesting and rational, the author first deciding what the most essential qualities for a given street are and adding together the respective ratings for each material. Thus, in a street having heavy traffic, he says that durability, cost of maintenance, resistance to traction and non-slipperiness are very important. Accordingly, the best granite stands at 44; asphalt, 40; brick, 37; belgian block, 33; cobblestone, 26; macadam, 23. Besides this study of materials, the chapter treats of methods of paying for pavements, their annual cost, the damaging effect of tearing up pavements for various pipe connections. It also gives some statistics of the mileage of various classes of pavements in eight leading American cities.

In the next division of the book a chapter is given to each of the principal classes of pavements, describing their construction and giving an analysis of their cost, based

on the labor and material involved, as shown by records of specific pieces of work.

One chapter is devoted to plans and specifications, and there is a very useful chapter on "The Construction of Street Car Tracks in Paved Streets." The latter is followed by a discussion of the widths of the component parts of what is legally known as a street; that is, the roadway, sidewalk and grass plots or areaways. In addition, this chapter treats of the construction of curbs and sidewalks, in a brief but satisfactory manner. The final chapter is on the location, design and operation of asphalt mixing plants.

One rarely sees a better balanced technical book than this, nor one which, on the whole, presents so large a subject in so thorough a manner, without burdensome detail and excessive bulk. It is just the right kind of a book for the intelligent municipal or other engineer, or the advanced student, who wishes a comprehensive review of the best current practice in street paving, written by a man who can rightfully interpret and supplement the experience of others by that gained in his own practice. The illustrations are right to the point; in fact, they may be cited as models of illustrations that illustrate.

SEWAGE AND THE BACTERIAL PURIFICATION OF SEWAGE.—By Samuel Rideal, D. Sc. (Lond.). New York: John Wiley & Sons. Cloth; 6 x 9 ins.; pp. 278; 9 plates and 36 figures in the text. $3.50.

This is the first comprehensive and satisfactory work on sewage purification which has been published since such bacterial methods as the septic tank and rapid filter beds came to the front. It differs from many, if not most, of the English papers and articles on sewage purification in being judicial rather than partisan, which is, or ought to be, a distinguishing feature between the two classes of writing.

The first three chapters of the book are devoted to the character of sewage and to its chemical and bacterial examination, which subjects are treated quite fully, even to some of the details of analytical practice. Then follow two chapters on the bacteria found in sewage and the chemical changes which they produce. These chapters are particularly welcome, at a time when almost every endeavor in sewage purification is to make use of bacterial agencies. In the succeeding chapters, irrigation, intermittent filtration, sterilization and chemical filtration are discussed, after which bacterial purification, as the term is now used, is taken up in detail. Chemical precipitation is fairly presented, although the author, like most other careful observers, seems to take it for granted that no one would now make use of it in planning new works. Towards intermittent filtration and irrigation the author is more favorably inclined, but he believes the former is unscientific, because of the reversal of the nature of the bacterial forces at work, being sometimes anaerobic and then aerobic, while irrigation, or sewage farming, may be practised to the best advantage after the reduction of the organic matter to soluble compounds, readily appropriated by plant life. In short, Dr. Rideal recognizes three stages in sewage purification, each requiring a separate class of bacterial life and action. In the first, the anaerobic bacteria break down the organic matter; in the second, semi-aerobic action takes place, carrying the dissolving process still further; while in the third, aerobic bacteria complete the changes, producing carbonic acid, water and nitrates. Septic action, whether in the septic tanks or in filter beds containing anaerobic bacteria, is essential to the first stage. Coarse filter beds are used in the second stage and fine ones in the third stage, the coarse beds producing nitrites and the fine ones completing the process by yielding nitrates. The three stages are characterized, each in a word, as hydrolysis, nitrosification and nitrification, and the last two, combined, as oxidation.

It is pleasing to Americans to note that Dr. Rideal has a better appreciation of the significance of the experimental work of the Massachusetts State Board of Health than most other English writers, but even he seems to fail to grasp its practical value, in relation to the numerous sewage purification plants in Massachusetts and elsewhere in America, which have been modelled on the teachings of those experiments. It is true that an abundance of sandy land, adapted to intermittent filtration, exists in Massachusetts and many other parts of the United States and Canada, and that such land is quite scarce in England. Most, if not all, the author's references to the Massachusetts experiments are to the special reports of 1890, but the experimental work at Lawrence has been continued to this day and has been reviewed in detail in each of the eight annual reports of the board issued since the date named. In addition, the latest report of the board contains the analytical results obtained by intermittent filtration at eight or more Massachusetts towns, during periods ranging from one to seven years, thus affording an opportunity to study the results obtained in practice, along the lines of the Massachusetts experiments.

A few geographical or like errors appear, such as locating the late Colonel Waring's Newport experiments on sewage purification in the state of New York, instead of Rhode Island; and the use of St. Lawrence, for Lawrence, Mass. On p. 159, in a brief discussion of garbage disposal, it is stated that "the 'Decarie' incinerator, Montreal, seems to be much used in Canada and the United States." Possibly there is a single small permanent plant in Canada and since Dr. Rideal wrote his book we believe a contract was let for one at Minneapolis, Minn., which is the nearest approach to one in the United States. Such errors as these are of minor importance, but they might well be corrected in another edition.

THE WATER-WORKS PLANT OF THE PEARL RIVER LUMBER CO., BROOKHAVEN, MISS.

By Wm. C. Porter, C. E.*

The Pearl River Lumber Co., organized in March, 1899, and located at Brookhaven, Miss., is probably the best-designed yellow pine lumber planing mill and manufacturing plant in the South. It has a daily capacity of 150,000 ft., and its mill work and lumber is of exceptional quality. In June of the present year the writer (of the contracting firm of McDaniel & Porter, McComb City, Miss.) was called in to design and build a water supply system for the company. In designing the plant the writer had the benefit of the large saw mill experience of Capt. A. E. Moreton, the original promoter of the present mill enterprise, and now its active manager. The outcome is believed to be a well-arranged plant for protection against fire, and for supplying water for its many uses, about a large manufacturing plant. A saving in the item of insurance charges alone of more than $100 per month proves its value.

Water is taken from a 6-in. tubular well, 450 ft. deep. It is of the purest character, and rises more than 300 ft. in the body of the well. An American Well Works air compressor discharges the water into a circular brick reservoir, 50 ft. in diameter and 12 ft. deep, holding 175,000 gallons. The wall of this reservoir is 13 ins. thick, laid in hard brick with Portland cement. The floor is of two courses of brick, one laid on edge, the other laid flat, and both in first-class Portland cement and sand, 1 to 3. The walls and floor are carefully coated with ½-in. of the same cement and then washed and troweled to a neat cement finish.

From the reservoir the water is taken by a Worthington heavy-duty underwriter's pump, capable of handling 750,000 gallons per day. The reservoir suction of this pump is also connected with a large pond, probably twelve acres in extent, used for the storage of logs and for their economical supply to the saws by water.

The water mains include 1,050 ft. of 6-in. 33-lb., and 4,600 ft. 4-in. 22-lb. cast-iron pipe, 13 valves and 18 2½-in. double nozzle Corey fire hydrants so placed in the pipe line as to best serve exposed points should fire occur in any of the numerous buildings.

Running under and into each mill, planing mill, dry kiln and storage shed is a 4-in. pipe with 4-in. valve in line. These are connected with 90° bends, with riser ends flanged and bolted to a 4-in. wrought-iron stand-pipe, leading up into the first and second stories of the building and there connected with 3-in. horizontal pipes, with numerous 2-in. nozzle valves and 50 ft. of hose, hung ready to use on the instant fire is discovered. Outside the buildings, at convenient points, will be placed 1,500 ft. of regular 2½-in. rubber-lined hose to be used on the fire hydrants, should it become necessary to fight fire from without.

The tank and tower will be 85 or 90 ft. high, and will hold 60,000 gallons. The tank connections are so arranged that either the residence section of the village, or the mill proper, may use water or cut it off without interfering with the supply of the other.

There is a 6-in. wrought-iron stand-pipe to be used to supply water to the three locomotives and the water tank car used by the company in its logging and hauling operations along its 15 miles of standard gage railroad track. An estimate of the cost of the plant, as outlined, is about as follows:

67 tons pipe and special castings	$1,850
Laying same and placing hydrants	625
Pump	800
Air compressor	800
Reservoir	1,000
Well	1,000
Suction pipe	200
Tank and tower	2,500
Pipe in buildings	500
2,000 ft. rubber-lined hose	750
Valves and hydrants	505
Total	$10,530

*McComb City, Miss.

EXPERIMENTS ON THE DIFFUSION OF LIGHT THROUGH PRISMATIC AND RIBBED GLASS WINDOWS.

In our issue of Aug. 13, 1896, we described briefly the results of some experiments made for the Boston Manufacturers' Mutual Fire Insurance Co., to determine the advantages of ribbed and wire glass for the diffusion of light. These experiments were made by Prof. Chas. L. Norton, of the Massachusetts Institute of Technology. The same gentleman has recently made a report of a similar series of tests conducted for the Associated Factory Mutual Companies of New England, and embracing a larger number of materials, which is published in the Bulletin of the Association, with an introduction by Mr. Edward Atkinson. The conclusions of this report are of such general interest that they merit mention, and accordingly we give an abstract of them here.

In his introduction to Prof. Norton's report, Mr. Atkinson says that prismatic forms of glass and also ribbed glass have been working a diffusion of light ever since they have been made use of for glazing. Ribbed glass has been used in the doors and windows of lavatories and other places for more than 40 years, to his knowledge; and prismatic forms of glass have been employed in the decks of ships, for deflecting light, for more than 50 years. He had his own attention first called to this matter in 1883, in inspecting the rough plate glass of rather poor quality in modern English cotton mills. He was told that this glass was preferred because the light was more uniform and better; he found this statement to be true, and commenced to experiment with window glass of different types. As a result of his investigation, he recommended for use in factories, workshops and schools what has since been known as "Factory Ribbed" glass, which is ribbed in true curves, inverse and obverse, 21 ribs to the inch. To place his theory on a scientific basis, Mr. Atkinson was instrumental in having the tests first referred to above made by Prof. Norton.

Since then other experiments have been made and one marked result of this research is the introduction of the Holophane glass shade, as made by the Holophane Glass Co., of No. 1 Broadway, New York. Mr. Atkinson says that the effect of this shade when put upon a Welsbach or powerful electric light, is as startling and effective as the use of the same type of ribbed glass in windows. For the latter purpose rolled glass in large sheets of prismatic form, with sharp angles, and corrugated and other types, are now offered at a very moderate cost, in competition with the improved ribbed glass now on the market. In view of this competition and of the claims made for these different kinds of glazing, the Associated Factory Mutual Companies determined to have a test made of their relative merits, for the benefit of the members of the association, and Prof. Charles L. Norton was again selected to make the tests.

An abstract of Prof. Norton's report follows: The result of the tests on a score or more of different glasses was: That we may increase the light in a room 30 ft. or more deep from three to fifteen times its present effect by using "Factory-Ribbed" instead of plane glass in the upper sash. By using prisms we may, under certain conditions, increase the effective light to fifty times its present strength. The gain is made in these cases when the sky-angle is small, as in the case of windows opening upon light shafts or narrow alleys. The increase in the strength of the light directly opposite a window in which ribbed or prism glass has been substituted for plane glass is at times enough to light a desk 50 ft. from the window better than one 20 ft. from the window is lighted by plane glass.

The samples tested were of two distinct types: First, glasses which were roughened or ribbed, primarily to blur distinct vision, and which happened to diffuse light; second, the special prismatic forms, especially designed to divert light from the original downward direction to one more nearly horizontal. In the first group nine different samples were tested, including ribbed glass with a wire net pressed into it, to increase its resistance to fire.

Of these, ground glass had little value except as a softening medium for bright sunlight; and common rough glass gave no perceptible change in the effective light. Of the ribbed glass, the

fine "Factory Ribbed," with 21 ribs to the inch, is distinctly the best, because of the greater sharpness of the corrugations. The "ribbed-wire" glass is about 20% less effective than the ordinary "Factory-Ribbed." The addition of a second corrugation upon the back of the plate, making "Skylight" and "Washboard" glass, is of no apparent value. The raised pattern imprinted on glass, like the "Maze glass," gives the widest diffusion, especially in bright sunlight. A raised figure on the back of "Ribbed" glass renders it less offensive to the eye in bright sunlight, but less effective in deep rooms.

In the second group the "Luxfer prism" consists of a plate smooth on one side and deeply notched on the other, with the teeth or prisms very flat, smooth and brilliant in appearance. The glass is clear white, and the prisms are used in canopies, and in vertical glazing in plates 4 ins. square, placed in copper or brass frames. This Luxfer glass is now made in large sheets for factory use.

The Solar prisms are made in small tiles; and it differs from the Luxfer in having the under face curved instead of plane. The Daylight prism is another form, made in large sheets and approximately of the same cross-section and general appearance as the factory Luxfer. The Mississippi prism glass is much like the others in cross section, with the ribs running in wavy instead of straight lines. Prof. Norton can detect no advantage in the waved over the straight-edge prism.

The tests were made in the Physics Lecture Room of the Massachusetts Institute of Technology. This room is 53 ft. deep, and 40 ft. wide, and has a sloping floor. In the middle of the west side, 8 ft. above the floor, two openings, 12 ins. square, were left in the large window. These openings were closed by shutters, and the remaining apparatus for observation is fully explained in the report.

The following conclusions were drawn from the tests made in this room: (1) The conditions in a room less than 15 ft. deep are such that, except with a sky-angle of less than 45°, it is not advisable to alter the general course of the light by using prismatic or ribbed glass. A "Maze," or "Silver Ripple" glass is ordinarily preferable in such cases; (2) When the room is 20 to 60 ft. deep, with a sky-angle of 60° or less, the ribbed and prismatic glass shows a great gain in effective light. A basement with prism canopies will be as light as a second story without them; and a first story with ribbed glass is distinctly brighter than a second story with plane glass. The report contains reproductions of photographs of the lecture room with the window glazed with the different types of glass.

Ribbed and Maze glass are also of great value in softening the light; especially in windows exposed to the direct sun. Maze glass will give an artist the much-desired "north light," in all weather and in all directions. For photography, it does away with cloth screens and gives a light of greater intensity. To be effective in rooms 20 ft. or more deep, however, the ribbed glass should be set with its ribs horizontal, and it should have thin white shades where the sunlight falls upon it. All tests were based upon the assumption that the diffusing glass was placed only in the upper half of the sash; if the lower sash is reglazed in the same manner a further increase of 25% may be expected.

Considering both expense and efficiency, Prof. Norton makes the following general suggestions: Use Maze or "Baird's" hand-made Silver glass in small rooms not more than 15 ft. deep. Use Factory-Ribbed in rooms 30 to 50 ft. deep, with sky-angles of 60° or more. Use Luxfer, Daylight or Solar prisms, or Factory-Ribbed in sheets in all vertical windows in rooms more than 50 to 60 ft. deep, and with sky-angles of less than 45°. With a sky-angle less than 30°, use Luxfer, Solar or Daylight prisms in canopies. As to cost, the Factory-Ribbed glass costs but little more than ordinary double-thick plane glass. The cost of rolled prismatic glass is not yet established; and cast prismatic glass is necessarily more costly than either of the others. Prof. Norton hopes that some manufacturer will produce a prismatic ribbed glass, made in large sheets and with a prism with rounded edges, at a cost commensurate with that of ordinary ribbed glass. He sees decided advantages in such a glass over one with a sharp-edge prism or with rounded corrugation.

THE NEW CLEAR-WATER RESERVOIR AT LOUISVILLE, KY.

On Jan. 26, the Louisville Water Co. will receive bids for a 37,500,000-gallon mechanical filter plant. This will be operated in connection with the old 100,000,000 settling reservoir, near which it is located, and a new 25,000,000-gallon covered clear-water reservoir, now under construction. The filter house is also under construction at present, being located over one compartment of the reservoir. Through the courtesy of Mr. Chas. Hermany, M. Am. Soc. C. E., Chief Engineer and Superintendent of the Louisville Water Co., we are enabled to show some views of the clear-water reservoir under construction, Figs. 1 and 3, a sketch of the steel ribs in the concrete vaulting, Fig. 4, and also to give a description of the work.

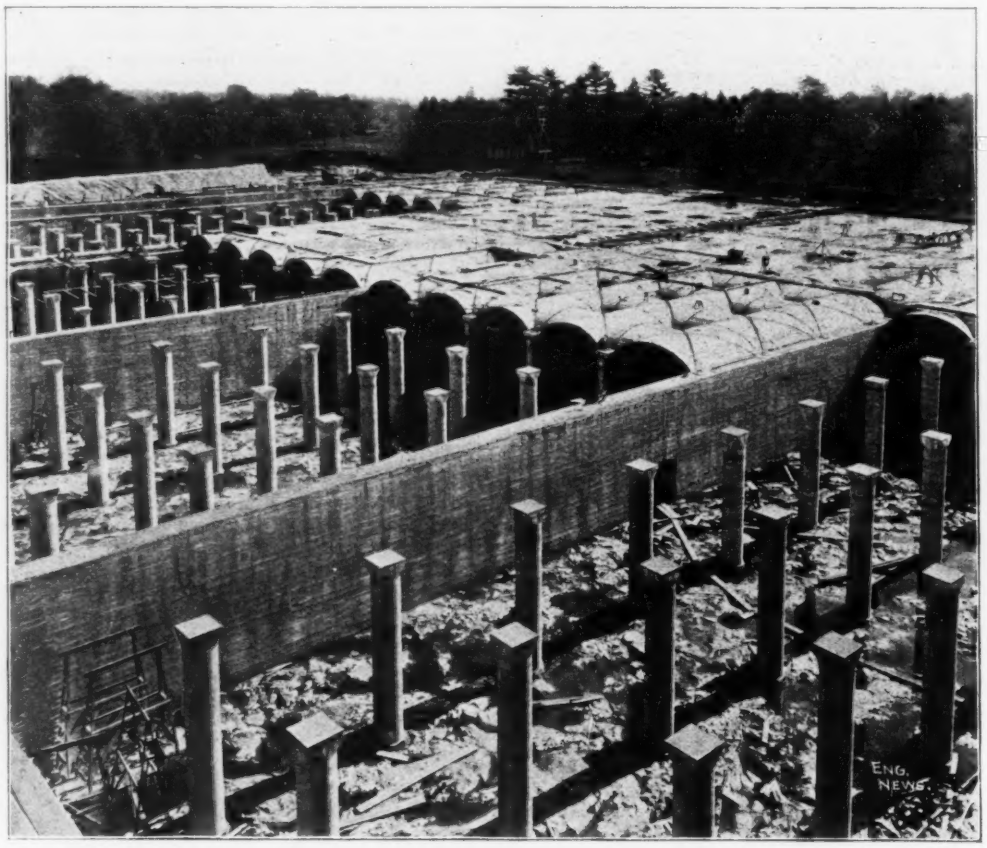


FIG. 1.—CLEAR WATER RESERVOIR UNDER CONSTRUCTION AT LOUISVILLE, KY.
Chas. Hermany, M. Am. Soc. C. E., Chief Engineer and Superintendent Louisville Water Co.

The reservoir is nearly rectangular in shape, 392 and 394 × 460 ft. It is divided into four nearly equal compartments, by three division walls running north and south and is covered with groined concrete and metal arches. The excavation was about 12.52 ft. in earth and 6.35 ft. in rock. The retaining walls are of concrete, with a thickness generally 0.7 of their height, but never less than 3 ft. To concentrate the cracking of the concrete walls, should any occur, the specifications provided for circular wells, 1 to 4 ft. in diameter, at each of the four corners and at about 30 ft. c. to c., in the exterior walls. In case cracks developed at these points the wells would be filled with concrete. The division walls are also of concrete.

The concrete vaulting is supported on concrete columns about 22 ft. c. to c., in both directions. The columns are about 3.4 ft. in diameter and about 21.11 ft. high. The arch construction is described in the specifications as follows:

> 14. The arches are to be what are called groined concrete metal arches of approximately 19 ft. span and 3.8 ft. rise. The intradoes and extradoes in these arches are to be arcs of circles of 13.775 ft. and 32.256 ft. radius, repectively, the concrete being 6 ins. thick at the crown and 36 ins. at the spring line in radial lines, and are to be constructed of Portland cement 1—2—4 concrete. These arches are to have built and imbedded within them concrete steel ribs 1½ × 5-16-in. in section, placed in eight half-pairs, resting upon each pier, four being placed at the groins of the arch and four midway between the apices of the groins. These ribs are to meet upon and are to be riveted to steel plates 16 ins. square and 5-16-in. thick, two plates in each pier, and side and division walls where ribs terminate, placed 28¼ ins., apart vertically, and stayed in the middle thereof by one ½-in. rivet passing through a short section of ½-in. iron pipe to stay the plates on. The two pairs of steel ribs intersecting each other at the apex of each groined arch are to be fastened together in a similar manner by a ¼-in. rivet and a piece of a ¼-in. wrought-iron pipe as a stay. This arrangement will result in connecting the steel ribs of every groined arch with those of every other through the 16-in. square plates built in the top of the piers. In placing the steel ribs and laying the concrete care must be taken to imbed every portion of each rib solidly in the concrete, as also the plates to which the ribs are attached. Both underneath, between and above the plates and ribs, the concrete is to be in complete and unbroken contact therewith. At intervals of about 12 ins. in the length of each rib there is to be a ⅜-in. rivet through the middle of the rib, with head on one side and burr on the other, as a means of securing an immovable conncetion between the concrete and the steel ribs. (See Fig. 4.—Ed.)

The haunches over the three westerly compartments are filled with earth; and over the easterly compartment with 1-3-9 Portland cement concrete, finished with a 1-in. sand and cement floor, forming the floor of the filter house, which is to be 116 × 392 ft., on the outside, with brick walls 24 ft. high.

THE DOMESTIC AND FOREIGN TRADE ADVANTAGES OF AN AMERICAN PARCELS POST.

An American parcels post is advocated by Congressman J. H. Bromwell, of Ohio, to be considered in connection with the proposed reduction in war taxes. To support his case he uses an elaborate report prepared for the Washington Board of Trade by Mr. Mahlon A. Winter, who points out the advantages in trade possessed by nations having parcel post treaties over the United States in similar tranactions. Under the rules of the Universal Postal Union an American merchant cannot send through the post, as samples of merchandise, any article having a salable value, or exceeding 12 ozs. in weight. These rules drive the American exporter to the international express companies; or compel him to pay foreign letter postage at 5 cts. per half-ounce, or $1.60 for a 1-pound package. As an example, Mr. Winter mentions a 3-lb. package destined for an interior town in the Argentine Republic. The express charges on this package amounted to $6.30 to the American exporter; while under the English postal law the same package could have been sent to its destination for 57 cts. Any Mexican importer could have sent 11 lbs. to the same place for 58 cts.; while a German could have sent 11 lbs. for

73 cts. As a practical result, the American article would have cost the importer $5.73 more than the same thing coming from England.

As showing the deplorable lack of transportation facilities, with which the American exporter has to contend, Mr. Winter mentions another case where an English merchant of Birmingham ordered a small bill of goods from a Minneapolis firm, the price of which was $9.30, and was compelled to pay $14.35 transportation charges. Mr. Winter says that the United States is the only great nation that does not now possess an elaborate system of foreign and domestic parcels post; and if it means to advance the interests of the nation as an exporter it must speedily correct existing evils by placing the manufacturers of the United States on a parity with those of other nations.

We now have a very one-sided parcels post convention with Germany, which is all in favor of Germany; and conventions have been negotiated with Mexico and a few minor republics in Central and South America, which are very satisfactory in their working.

Domestic parcels post in the United States is also an evident need; as a substitute for an express service that is conducted upon an arbitrary and oppressive basis and is excessive in its cost to the citizens. It is said that $90,000,000 per annum is now paid by the people of the United States for this express service. As showing the public advantages of a parcels post system, it is pointed out that in the great State of Pennsylvania, with its enormous trade demands, there are only 919 express offices; while there are 5,206 post-offices where this same business could be transacted under a system of parcels post and at very little additional expense. If this illustration were applied to the whole country, we begin to realize what the parcels post would mean to the nation.

Mr. Winter presents a very instructive table showing the cost of an 11-lb. express package, sent from New York to each State and Territory, and then compares these express charges with what it would cost under the German domestic parcels post laws. This table shows that a German or Mexican exporter could now send goods to these same localities at less cost in all cases than the American; and in some cases the saving to the foreigner would be as much as $3.29 on the 11-lb. package. Under the German law the postage on the 11-lb. package for all parts of the United States would be 12 cts.; as compared with $3.77 expressage to Arizona, for example. Further, while there are 20,155 express offices in the United States, there are 75,000 points of delivery in the form of post-offices.

The cost of sending parcels anywhere in the United Kingdom ranges from 6 cts., for a 1-lb. package, to 24 cts. for an 11-lb. parcel. In Germany it costs only 12½ cts. to send 11 lbs. from any one post-office to any other; and in Switzerland the same weight costs 8 cts. postage. For the year ending March 31, 1900, the British Postmaster General reports 74,448,000 parcels sent through the mails of the United Kingdom, or about two packages for each inhabitant. The London Board of Trade report shows that in the fiscal year 1899-1900, the value of goods exported by foreign parcels post amounted to $20,495,670; and the goods imported in a similar manner amounted to $5,444,728. A table setting out the growth of the system in England, from 1884 to 1899 inclusive, shows that the number of parcels per annum thus sent increased from 22,910,000 in 1884, to 71,913,000 in 1899; and the gross postage revenue increased in the same time from $2,475,162 to $7,295,742. Of this gross revenue, $3,858,827, or 55%, was paid to the railway companies for transportation. A similar table giving the experience of other foreign governments in introducing the parcels post system indicates equal success and rapid growth.

Mr. Winter, in discussing the alleged disadvantages of the adoption of a parcels post system in this country, clearly shows that its chief opponents are the railways and existing private express companies. He quotes the vice-president of one of our leading Western railways as claiming that every pound of freight to be transported is the legitimate source of revenue to the railways; and such freight should be transported in freight cars, and not by the government as mail in mail cars Other railway men, however, regard the express companies as unnecessary middlemen, who do a large share of the business that properly belongs to the railway alone. Mr. Winter points out that it is not the purpose of the promoters of domestic parcels post to establish a public express company for the transport of any and all classes of goods. They simply want to enlarge the functions of the mail service so as to include the carriage and handling of packages of a reasonable bulk and weight, with ease, facility and profit. Mr. Winter demolishes the charge that such a system would permit the Western consumer to buy direct from the Eastern manufacturer, and thus destroys the business of the Western merchant, by showing that this merchant can buy his goods at from 20 to 60% discount on the price to the consumer; and can thus sell them for less than the consumer could possibly buy.

Until the present policy is changed it is bound to injuriously effect our commercial interests abroad. We now supply only about 10% of the goods imported by South America; and the reason given by Mr. Winter is that we are strangling the only feasible means of cheap and efficient package communication with these countries. The situation is tersely expressed when it is pointed out that England can now send an 11-lb. package to Mexico—for example, for 84 cts., and Germany can send the same for 58 cts., while the American merchant—or the Mexican importer rather, has to pay $1.32 postage on the same weight. Under such conditions it is little wonder that Europe dominates the trade of Mexico. An extended table in the report of Mr. Winter contrasts the charges on an 11-lb. parcel sent by post from England, Germany and the United States—when the latter is possible—to various parts of the world, with the charges now made to these points by private express companies. This table is a telling commentary upon existing methods, and in itself explains why business with American merchants is seriously handicapped by comparatively excessive transportation charges.

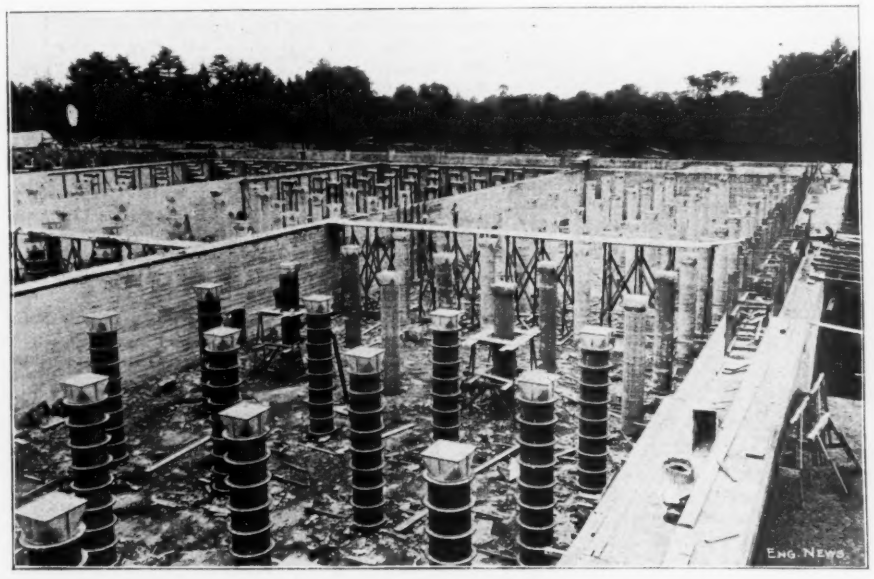


FIG. 2.—COLUMNS READY FOR CENTERING AND CENTERING READY FOR ARCHES.

FIG. 3.—STEEL RIBS IN FOREGROUND, READY TO BE EMBEDDED IN CONCRETE VAULTING.

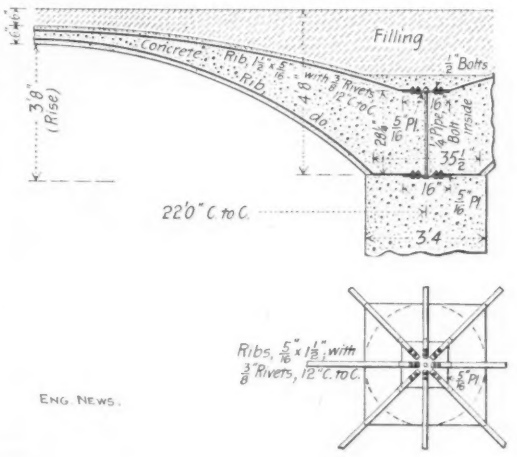


Fig. 4.—General Sketch Showing Arrangement of Steel Ribs Embedded in Concrete Arches.

STEP-JOINTS AND STEP-CHAIRS FOR RAILS.

Where rails of light and heavy section come together, a very common method of splicing them is to bend flat splice bars to fit the webs of both rails, the lighter rail being supported by blocking to bring its head level with that of the heavier rail. This is rather a makeshift device, however, and rarely makes a good or tight joint. A stronger and more effective device, which is now quite extensively used, is shown in Fig. 1. It consists of two heavy malleable iron splice bars made to fit the flanges and heads of the two rail sections, and having four or six bolts through the rails, according to the standard joint of the railway. Two bolts below the rails hold the bars tightly together, and there are flanges with spike slots, made to fit either a supported or suspended joint, as required. These joints are very generally used at turnouts, to connect the lighter rails of the siding with the heavier main track rails which are laid through the turnout. The joint shown in Fig. 1 is used for this purpose on 56 and 75-lb. rails on the Illinois Central R. R. Similar joints, but connecting 67 and 85-lb. rails, are used on the new Omaha extension of this line, as described in our issue of

Jan. 25, 1899. In this case, the joint is supported, and the lower bolts are on either side of the joint tie. Joints made for the New York Central Ry., connecting 75 and 80-lb. rails, have end flanges resting on the shoulder ties and the two bottom bolts fit between these ties. Similar joints are used on street railways for connecting the deep girder rails used in streets with shallow T-rails used on suburban lines. These joints are made by the Atlas Railway Supply Co., 1525 Manhattan Building, Chicago, and we are indebted to this company for the drawing reproduced in Fig. 1.

In the same connection, reference may be made to the use of step-chairs to enable light guard rails to be used at frogs where the track rails are of heavier section. This plan, as adopted on the Southern Pacific Ry., is shown in Fig. 2. The 10-ft. guard rails at frogs have each three of these

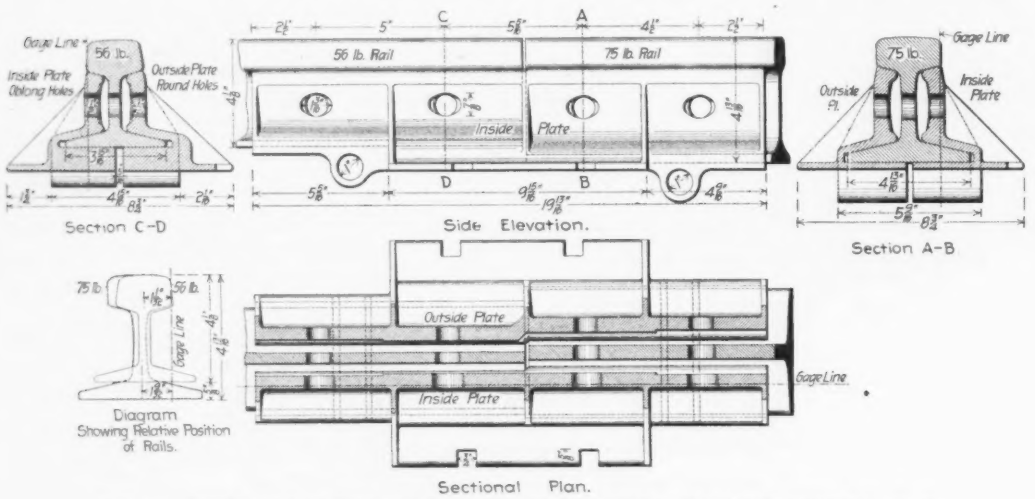


FIG. 1.—STEP JOINT FOR 56-LB. AND 75-LB. RAILS; ILLINOIS CENTRAL R. R.
Atlas Railway Supply Co., Makers.

combined chairs and braces, and the 6-ft. guard rails ahead of the switch points have two chairs each. The base of the chair is 5½ × 5 ins. The guard rails are bolted to the track rails by ⅞-in. bolts, pipe spacing sleeves giving the proper width of flangeway. The end of the bolt is split, and is opened out after the nut is screwed tight. The track rails and guard-rail chairs rest on special tie-plates 12 ins. long. Somewhat similar chairs are used to raise and support light sidetrack rails near the step-joints by which they are spliced to heavier main line rails.

THE PROPELLING MACHINERY OF A TORPEDO-BOAT DESTROYER.*

By William David Seton Brown, Stud. Inst. C. E.

Although the torpedo-boat has ceased to be a novelty, and a speed of 30 knots per hour is regarded with indifference, a few particulars of the machinery by which this speed is attained, and of improvements suggested by recent experience, may prove of some interest. The author proposes to confine himself to the propelling machinery of the enlarged torpedo-boat known as the "destroyer."

BOILERS.—The most characteristic feature of these vessels is the boiler. With the exception of H. M. S. "Havoc," "Hasty," "Dasher," and "Charger," which were fitted with the locomotive-type marine boiler, all our destroyers owe their speed chiefly to what is known as the express, or small-tube water-tube boiler. The locomotive boiler which was for a long time the standard boiler for small craft had been pushed to its utmost limit; at high powers its limited grate area had to be compensated for by a high rate of combustion, to which it was not suited, and leakage at the tube-ends was frequently the result. The express boiler, however, presents conditions exactly the reverse. Apart from its superiority in point of weight, its ample grate area has obviated the necessity for such high rates of combustion, though its rapid circulation and unexposed tube ends enable it to stand the most severe forcing, should occasion demand it. Several vessels of the torpedo-gunboat class and a third-class cruiser are having their locomotive boilers removed and water-tube boilers substituted; in fact the locomotive-type marine boiler may be said to be obsolete. The types of express boiler chosen for H. M. 27-knot destroyers were the "Thornycroft," "Yarrow," "Normand," "Blechynden," "Reed" and "White." They all consist of an upper drum, forming the steam space ("White's" boiler has two upper drums) connected to lower drums, or water pockets, by a number of small tubes forming the heating surface, and, with the exception of the "Yarrow" boiler, by a few large pipes, commonly called "down-comers," forming passages for the downward flow of water. The grate occupies the space between the lower drums, and the products of combustion impinge on the small tubes on their way to the smoke-box.

*From the Minutes of Proceedings of the Institution of Civil Engineers, Vol. cxli.

BOILER-TUBES.—The tubes for these boilers are now invariably of solid drawn steel, generally 1-in. to 1¼ ins. in diameter and 3-32-in. thick. Some of the earlier destroyers had copper tubes, but they proved unreliable, and have been replaced by steel tubes. Copper loses its strength at high temperatures to such an extent as to render it unfit for the tubes of high-pressure water-tube boilers. Tubes are galvanized externally to reduce external corrosion from damp when lying up. They are cleared of soot when under steam by a jet of steam from a portable nozzle connected to a flexible pipe. Air-tight doors are provided in the casing for this purpose. With the exception of those of the "Reed" boiler, the tubes are expanded into their drums or tube-plates, the friction of the tube joints being sufficient to prevent the drums being blown apart by the pressure on the areas opposite the tube ends. The curved tubes used in these boilers do not exhibit any tendency to straighten under pressure as might be supposed, while straight tubes generally acquire a slight curvature. The necessity of expanding tubes into very small drums led to the invention of the Thornycroft tube expander, which is turned and fed through bevelled gearing by a shaft long enough to reach the whole length of the drum. The fire-boxes are lined at their ends with fire-brick, and the lower drums at each side of the grate are also protected with the same material. The casing usually consists of two thicknesses of 1-16-in. sheet steel with asbestos cloth between. The fire-bars are of wrought bar-iron lightened by numerous holes and riveted in pairs with distance pieces between.

CIRCULATION.—Considering generally the elements which make for efficiency in boilers of this type, the most important is rapid circulation. Circulation of some sort is absolutely essential to prevent the tubes overheating at

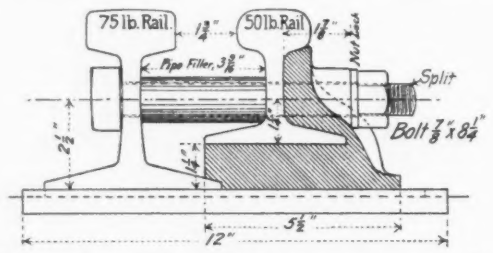


Fig. 2.—Step Chair and Brace for Guard Rails; Southern Pacific Ry.

high rates of combustion, but the more rapid it is, the greater is the efficiency of the tubes as heating surface, owing to the greater amount of heat they are able to absorb. In this respect the express boiler has the advantage, compared with the usual forms of large tube boiler, that its tubes are comparatively short and direct, and more nearly vertical; also, each tube discharges into the steam drum independently of the rest, and the small diameter of the tubes causes a more rapid generation of steam. The cause of circulation has been the subject of much controversy, and though opinions still differ on the theoretical side of the question, all are agreed as to the steps that should be taken in practice to secure a good circulation. In reference to the economy of the express boiler, widely varying results are brought about by apparently trivial, and in most cases, preventable causes. The first condition of economy is perfect combustion. The express boiler has a large grate, which requires a thin but even fire; if too thick in places the air cannot penetrate and the coal clinkers; if too thin, the air enters the fire-box insufficiently heated.

STOKING.—Most destroyers have four boilers, but some have only three, while in others there are eight. In all cases there are two stokeholds. Coal is stored in bunkers along the sides of the boiler space, and in an athwartship bunker forward. The forced draft is supplied by fans, generally having vertical shafts, and situated close under the deck. In this case they are single-breasted, being joined directly to the base of their cowls, and are driven by single-cylinder horizontal engines, the full speed of which is about 400 revolutions per minute. Double stokeholds, that is, with fires back and front, have two fans, one on each side of the ship; single stockholds have one central fan. The air usually enters the ash-pits direct, through thin doors which swing inwards and close when there is no excess of pressure on the stokehold side. An excellent system adopted in the "Yarrow" boiler is to take in air through similar doors high up in an outer casing; there it is heated and helps to keep the casing cool, the hot air passing on to the fire. This arrangement provides an additional safeguard against flames being forced into the stokehold by an occurrence of back pressure.

BOILER FEEDING.—Owing to the small quantity of water contained in these boilers and the consequent rapid evaporation the feed system assumes unusual importance. Some form of automatic feed is generally considered almost indispensable, though one foreign government prefers to trust to the human element rather than to any mechanism. Nearly every express boiler has its own form of automatic feed apparatus, but most of them consist of a valve worked by a float either within the steam drum or in a chamber connected with it. Such an apparatus is always capable of adjustment to suit different rates of combustion or for operating the valve by hand; in the Thornycroft regulator the fulcrum of the float is raised or lowered by a screw outside the steam drum; in the Blechynden regulator the valve seat slides within its casing and can be adjusted by an external screw, so that the valve can be opened either automatically by the float moving the valve spindle, or at will by moving the valve seat. Both of these forms have been found to work satisfactorily in practice. Messrs. Yarrow have tried a form of automatic feed in which the steam-pipe to the feed-pump is led from a conical pan placed in the steam-drum with its upper edge at the normal water-level, the object of this being to enclose a body of water unaffected by the disturbance of the surrounding water. So long as the top of the pan is uncovered, steam is supplied to the pump, but when the pan is covered with water the pump is choked with the water that comes over in the pipe. Adjustment is effected by raising or lowering the pan, there being a joint in the pipe connecting with it. This arrangement necessitates a separate pump for each boiler. An installation of Normand boilers has been fitted, in which the steam-drums are connected by pipes below the water-level. This has the effect of steadying the water-level in each boiler, and it is only necessary to watch one boiler; but it adds to the weight and complication of pipes, as valves have to be fitted to enable any boiler to be shut off.

Opinions differ on the subject of the best place to admit the feed. At first it was usually admitted in the lower drums, but the practice soon became general of admitting it into the steam drum, chiefly with the object of assisting circulation by allowing it to flow downwards inside the boiler, and also to distribute it more evenly. Recent experiments, however, with the Blechynden boilers of H. M. S. "Pactolus" have shown an increased efficiency when the feed is admitted at the lower drums. Mr. Yarrow has described an interesting series of experiments in connection with feed-admission. He has found that by partitioning off the outer rows of tubes and admitting the feed to these first, the same number of tubes will absorb a greater amount of heat from the fire than if the feed is permitted to follow its natural course in the boiler. This result has verified the theory that the hottest gases should meet the hottest tubes, and vice versa, and is another illustration of the efficiency of the feed-heater placed in the uptake, often called the economizer. This efficiency is due to the fact that the difference in temperature between the cold-feed and the uptake gases is sufficient to cause a useful exchange of heat, whereas if the same gases acted on a surface containing hotter water the exchange of heat would not be worth considering. It seems rather wasteful, however, to use part of the boiler as a feed-heater, since a feed-heater requires no provision for circulation and can consist merely of coils of small pipes. There is little doubt that the boiler of the future will receive its water from a heater at the boiling-point due to its pressure, as it has been proved that a marked economy can be obtained by heating the feed to boiling-point, even by live steam from the same boiler.

The system of feed-pipes and pumps is in duplicate, being termed main and auxiliary. The main feed-pumps are preferably placed in the engine-room, where they are under better control, and are free from the ruinous effects of coal-dust, but the auxiliary feed-pumps are placed in the stokehold to be available in case of emergency,

such as the failure of the automatic feed. Filters are fitted either on the suction or discharge side of the feed-pumps, and consist of layers of brass grids covered with the filtering composition, which is easily replaced when clogged up, a by-pass being fitted for this purpose. Suction-filters are the lightest, since they are not subject to pressure, but the action of the discharge-filters is more certain. The latter are fitted with relief-valves to prevent excessive pressure in the pipes owing to the filters getting clogged. A reserve fresh-water tank is fitted, generally built into the ship's frames, for making up the feed. An evaporator and distiller is also fitted for producing fresh water both for drinking purposes and for the boilers. No oil has been used in the cylinders of these engines, and no trouble has been caused by the want of it, in spite of their high piston-speed. However, enough oil always finds its way into the steam by means of the rods to render filters a necessity when express boilers are used.

STEAM-PIPES AND FITTINGS.—Steam-pipes are now of solid drawn steel, when of larger diameter than 1½ ins., and below this size solid drawn copper pipes are allowed; the earlier destroyers had solid drawn copper pipes considerably above this size. Flanges are screwed on for small sizes and riveted for large sizes. Bends and T-pieces are of gun-metal or cast steel; the latter is rapidly growing in favor, as reliable castings can now be obtained much thinner than was formerly practicable, and at a reduced cost. There are usually two ranges of main steam-pipes, on opposite sides of the ship, one from the forward, the other from the aft group of boilers, having stop-valves and a cross-connection in the engine-room, as well as the boiler stop-valves and regulator-valves on the engines. They slope gradually towards the engines, and are drained by steam-traps discharging into the feed-tank. The auxiliary engines are supplied with steam by a separate range of piping having separate stop-valves on the boilers, and they can exhaust into the condenser or through a pipe at the side of the funnel. A silent blow-off is fitted from the main steam-pipe to the condenser. Gage-glasses continue to be of glass, though they are an endless source of nuisance and sometimes danger at high pressures. Mica has been tried, but it soon discolors; it may be said that a trustworthy means of rendering the water-level visible and resisting high steam pressures has yet to be found. Water-nozzles are fitted in the furnace-fronts for drenching the fires. The steam pressures employed in these vessels range between 180 lbs. and 250 lbs. per sq. in. The latter is not so high as the pressure employed in the Belleville boilers of H. M. cruisers and battleships, in which the boiler pressure is 300 lbs. per sq. in., but in their case it is reduced to 250 lbs. per eq. in. at the engines, while no reducing valves are used in destroyers.

ENGINES.—The type of engine adopted in these vessels has been either the three-crank or the four-crank inverted triple expansion engine. In choosing between the two types a consideration secondary only to that of weight and space is that of balancing. Since the magnitude of the inertia-forces in an ordinary steam engine varies with the mass, the stroke, and the square of the number of revolutions per minute, it will be seen that of two engines having the same piston speed and the same weight of moving parts, the one with the shorter stroke and higher rate of revolution causes most vibration, and in a destroyer the highest piston speed and the highest rate of revolution are combined. The effect of these forces is greatly magnified by the light scantlings of the hull, the stiffness of which cannot be relied upon to the extent possible in larger ships. The three-crank engine was more common in the 27-knot boats, but in the 30-knot boats the four-crank engine has in many cases taken its place, and has practically become the standard type for high-speed engines. The three-crank engine, however, has much in its favor; its twisting moment is more uniform, it takes up less fore and aft space, and has fewer working parts, with a correspondingly reduced risk of breakdown. Though three cranks at 120° would constitute a statical balance about the center of the shaft if the pistons were of equal weight, dynamical stresses are set up by the successive acceleration and retardation of each set of moving parts, and though the sum of the forces set up in a given direction is nearly equal throughout the stroke to that of those set up in the opposite direction, they do not act in the same plane, and therefore constitute a couple, varying with the distance between the planes in which the resultant opposing forces act. This couple tends to cause the ends of the engine to move in opposite directions, this tendency being greatest in the vertical plane, as the forces due to the vertically reciprocating parts are then added to the centrifugal force of the revolving weights.

BALANCING.—Vibration in the three-crank engine has, so far, been met by balance weights placed on the crank webs. By this means all forces due to the revolving parts can be eliminated, but it is obvious that if the revolving balance weights be increased till they balance the vertical forces of the reciprocating parts, horizontal forces of the same amount are introduced, and thus the effect is merely to change the vertical forces to horizontal. Indirect though this method may seem, it has met with considerable success in reducing vibration, as trials with and without balance weights have proved, and seems to show that a vessel of this type is stiffer in a horizontal than in a vertical direction, at any rate at the bed-plate, where the forces are applied. It is sometimes considered sufficient to balance the revolving parts, while a good compromise seems to be found in proportioning the forces to the stiffness of the ship in the direction in which they act, thereby reducing the maximum force exerted. The increasing preference shown to the four-crank engine is largely due to a desire to obtain a self-balanced engine, though it has the important advantage of keeping the diameter of the cylinders, and consequently the breadth of the engine, more uniform, two low-pressure cylinders, very little larger than the intermediate, being substituted for the single larger cylinder. Obviously the length of the engine is considerably increased, but it is in breadth of engine-room space rather than in length that the designer is cramped.

Returning to the question of balance, though the four-crank engine lends itself to obtaining an almost perfect balance with a correct disposition of cylinders and crank angles, until quite recently engineers have been content to place the cylinders in their natural sequence, with the high-pressure crank directly opposite to the intermediate-pressure crank, and the two low-pressure cranks opposite each other, the high-pressure and intermediate-pressure cranks making an angle of 90° with the low-pressure cranks. In this case there are two distinct unbalanced couples set up, the one reaching its maximum when the other is at zero. The magnitude of the couples, however, is in no case as great as the couple set up by a three-crank engine of the same size, unless No. 1 crank be placed opposite No. 4 crank, which is the worst sequence possible. The opposite cranks, therefere, should be brought as close together as the cylinders will permit.

The Thornycroft engine is the outcome of an effort to get rid of even this limitation, and to reduce the couple to a negligible quantity. In this engine the two adjacent crank-pins are joined by a single web without a middle bearing, the cylinders being placed radially at a slight angle on each side of the vertical. The adjacent cranks make with each other an angle of 180°, less the angle between the center lines of their cylinders, so that both cranks reach the end of their strokes simultaneously. This arrangement has not only attained its object in reducing vibration to a minimum, but reduces the pressure on the main bearings. The pressures on the crank-pins to a great extent counteract one another, and the main bearings, instead of receiving the full load due to the steam pressure, receive little more than that due to the couple depending on the fore and aft distances between the crank-pin centers. In other words, supposing the fore and aft distance between the main bearing centers to be double the distance between the crank-pin centers, the pressure on the main bearings would not be much more than half that on the crank-pins. It is not exactly half, owing to the inclination of the cylinders to one another. Further, the load on the main bearings being reduced, the load on the columns is correspondingly reduced, the fitting bolts connecting the adjacent cylinders being in shear. There is a slight tendency to horizontal vibration in this engine, owing to the sideways movement of the parts, but the effect is scarcely noticeable. Mr. Thornycroft has pointed out and illustrated by the simple means of two pieces of twisted wire that a pair of cranks without a middle bearing in transmitting a twist has not the tendency to displace the center of the shaft that a single crank has, since any distortion in one crank-pin and any deflection in one crank-web is neutralized by a similar condition in the opposite crank. He attributes many failures of crank-shafts to their being brought out of line by the distortion of the cranks, but, considering the severe bending stresses tending to throw a crank-shaft out of line, this slight tendency seems almost trivial, especially as it cannot occur unless the cranks be not stiff enough to transmit the twist without distortion. The claim to reduced initial friction with this type of engine compared with the three-crank engine seems amply justified by progressive trials with the two types of engines, the initial friction in each case being obtained by producing the curve of indicated thrust to zero speed. This type of engine has the slight disadvantage of having very short eccentric rods for two of the valves, the other two having a good length of rod; this is caused by the link motions being at different inclinations, but suspended from a common weigh-shaft at the side of the engine. It is also possible that the cylinders may after a time be found to have worn slightly oval owing to their inclination from the vertical. The ordinary vertical four-crank engine has been found to run fairly steadily when the opposite cranks have been brought as close together as possible, but where they have been separated by a piston-valve balance-weights have as a rule been found necessary.

The combined piston valve adopted by Messrs. Belliss in H. M. S. "Swordfish" and "Spitfire" must of necessity be placed between the two cylinders with which it is connected. It amounts to placing two valves one above the other on a common spindle and driven by one set of link motion, the valve-chest being common to both cylinders. If the valve-settings of both cylinders are the same, then the cranks must be opposite, or at any rate nearly so, if different valve-settings are required. This type of valve reduces the fore and aft length of the engine considerably without increasing its breadth, and obviates the cost of two sets of link motion; it has, however, the drawback of presenting a more complicated casting, which is not desirable with such thin metal, and the setting of one valve cannot be altered independently of the other; it also necessitates the centers of the opposite cranks being a greater distance apart. To reap the full benefit of the four-crank engine, the crank angles should be arranged so that there is no resultant couple and very little resultant force. It is of course desirable that there should be no resultant force, but this is not at present practicable owing to the disturbance caused by the obliquity of the connecting-rod.

LOCATION OF ENGINES IN THE HULL.—With the exception of those built by Messrs. Laird, which have their engines in the middle of the ship, as being the position where the hull is least susceptible to vibration, all the British destroyers have their engines aft of the boiler space, placed side by side, with no middle bulkhead. The favorite arrangement in America seems to be to place one engine-room forward of the other and separated from it by a water-tight bulkhead, the engine space occupying the middle of the ship, and the boilers being in two groups, one forward and one aft. This arrangement has the advantage of completely isolating each set of engines and boilers, and also that the coal-bunkers, which, contrary to English practice in these vessels, are situated on either side of the engine space, may afford a slight protection to the engines, but, on the other hand, the engines occupy a much larger portion of the ship than if placed side by side.

Returning to English practice, the condensers are placed in the wings with the ordinary type of engine, and are made long in proportion to their diameter, in order to reduce weight and also to give more room for a gangway between the engines. The length of the condenser is limited by the necessity of having sufficient clear space at one end for drawing tubes. In the case of the Thornycroft engine, which is broader and shorter than the ordinary engine, the condenser is placed aft of the engines. The center lines of the shafts have always to be slightly inclined from the engine-room downwards, to immerse the propellers, and as a rule they are slightly inclined outtowards, to bring the engines as close together as possible. Some of the earlier destroyers were arranged to secure a broad gangway between the two engines, there being no room to pass between condensers and engines. This is the best arrangement for vessels of very narrow beam, but as the screws (with the exception of those of H. M. S. "Conflict") revolve outwards, a good view of the engines is not obtainable from a center gangway, as the piston-rods and connecting-rod top ends are to a great extent hidden by the guides. As the distance between the engines is increased, the centers of their shafts have to be raised, owing to the rise in the ship's bilge; consequently the general practice is to secure a free gangway at the outside of each engine, where the only unavoidable obstructions are the exhaust pipes to the condensers, and to bring the engines as close together as the space necessary for steam pipes will admit.

AIR PUMPS.—In most of the 27-knot boats the air-pump is placed forward of the engines in a continuation of the crank-pit and is driven by a connecting-rod from a small crank-shaft, which forms a continuation of the main crank-shaft. Height is saved by adopting the trunk form of bucket, the connecting-rod eye working on a pin secured at the lower end of the trunk. In this arrangement the air pump occupies no room that might be otherwise useful, as the floor plates can be carried above it, a lid being fitted for inspection and oiling. As, however, the stroke of the pump is limited to 4 ins., the diameter, and consequently the clearance, is excessive. It has also proved troublesome on account of the bearings becoming heated, which is probably due to some extent to its being out of sight. For these reasons it has been abandoned in the 30-knot boats, in favor of the usual lever-driven pump, driven from the aft low-pressure cylinder and placed on the outside of the engines; it does not then obstruct the gangway as there is room to pass in the space left for drawing the condenser tubes. In a fore and aft direction, space is most required at the forward end, as in nearly every case the hand gear and pressure gages are brought to this end and room has to be found for two main feed pumps, two circulating pumps, an evaporator, distiller and engine, a fire- and bilge-pump, in some cases feed-heaters and separators, and an air-compressor for the torpedoes. The steering engine is always placed on the aft engine-room bulkhead, between the thrust blocks, and the electric-light engine is placed in the next compartment abaft the engine-room, which is used as a galley and a store.

VALVES.—The main-engine cylinders are not jacketed, the usual thickness for high-pressure cylinders being ¾-in. They are independent castings (with the exception of Messrs. Belliss's arrangement, already mentioned) connected by brackets top and bottom; each cylinder has its own valve chest cast with it; steam joint connections, such as are found in the merchant service, are not permitted. Since the expansion of the line of cylinders is a condition to be reckoned with, it is usual to fit the liners between these brackets when the cylinders are hot. The framing has to yield to the expansion in any case where the cylinders are bolted together, but this method ensures the cylinders being in line under working conditions. Pis-

ton valves are always fitted for the high-pressure and intermediate-pressure cylinders, and as a rule also for the low-pressure cylinder. The high steam pressures employed render these a necessity for the high-pressure and intermediate-pressure cylinders, while even for the low-pressure cylinder a piston-valve and chest is lighter than a flat valve and chest, though it takes up more room. It has greater freedom in running at high speeds, and if carefully fitted, the steam has scarcely time to leak past it. Piston valves are of cast iron, though aluminum has been tried, and have no packing rings, but often have a number of small grooves on the working face, in which the condensed steam collects. These grooves have been found to assist in keeping the valve tight and in lubricating the working faces. All flat surfaces, such as steam ports, are stayed with fine thread steel stays screwed into bosses in the casting, and calked at their projecting ends. Steam is admitted between the steam ports to the annular space round the valve, exhausting at the outer edges. The valve chest glands are then subject to steam at a lower pressure than with the reverse arrangement. When a flat slide valve is used, a compact arrangement is to exhaust the steam through the back of the valve chest, the usual relief ring being employed to keep the passage tight.

SHAFTING.—The crank-shafts are of mild steel and are forged in one piece, the shaft and crank pins being hollow. The bore is usually half the diameter or slightly more. The crank-webs have their corners bevelled or rounded to save weight, and balance-weights, when required, are driven on to mortises on the crank-webs and secured by strong studs. In the coupling between the crank-shaft and the thrust-shaft, "drivers" are usually employed instead of the ordinary fitted bolts, to prevent the possibility of any thrust coming on to the crank-shaft. They are held by nuts in taper holes in the thrust-shaft, coupling-flange, and fit easily in the holes of the crank-shaft coupling flange, the two flanges being about ¼-in. apart. The coupling between the thrust- and tail-shafts consists of a swelling in the thrust-shaft, into which the end of the tail-shaft fits, and is secured by one or more cotters. This is the simplest form of coupling where the tail-shaft has to be drawn outboard and access is limited. The cotters transmit both the twist and the thrust, whereas in the ordinary form of loose coupling special provision has to be made for transmitting the thrust. The tail-shaft is carried at each end by cast steel tubes lined with white metal, the forward of which is driven into a tube built into the ship and the after into what is generally known as the A-bracket, both of these parts being bored out in position. The tail-shaft is open to the sea for the greater part of its length, but though exposed to rust, there are no brass liners to set up galvanic action. Zinc rings are fitted on the shaft at the forward end of the propeller to minimize galvanic action caused by the latter. The aft end of the tail-shaft is completely covered by the propeller nut, which in turn is covered by a light brass cone which follows the outline of the propeller boss and fills up the vacuum which would otherwise be caused there.

PROPELLERS.—The propellers are three-bladed, the blades being in one casting with the boss. They are of high strength bronze, such as manganese- or aluminum-bronze, or Stone's metal. With the exception already mentioned they revolve outwards, as the outward current tends to throw clear any floating debris or ropes, instead of drawing them inwards. In large naval vessels, which have their propellers more deeply immersed, this consideration is not so important, and the latest cruisers have propellers revolving inwards to bring the open fronts of the two engines towards the center of the ship for convenience in handling. In a series of experiments recently described before the Institution of Naval Architects, Mr. R. E. Froude has found that there is practically no difference in efficiency depending on the direction of revolution. Experiments have proved that a high-speed propeller of small diameter, large blade area and coarse pitch is the most efficient, as the reduction of surface friction secured by the lower average velocity compensates for the coarser angle of blade. The slips obtained on successful trials in these vessels range between 15% and 8%, and as a rule the best results are obtained with the higher slips. At a certain point, however, increase of slip ceases to be attended by increased thrust. This is probably chiefly due to the phenomenon now known as "cavitation," which was met with in a marked degree in the first propellers of the "Daring," as described by Mr. Thornycroft in the Paper already mentioned.

THRUST BLOCKS AND ENGINE FRAMING.—The thrust blocks are of cast iron, and are of the solid type, bushed with white metal and water jacketed; they are generally carried on cast-steel bearers bolted to longitudinal girders of angle or channel section. These girders are sometimes of cast, but more commonly of rolled steel, and run the whole length of the engines from the thrust blocks to the air pump, if the latter is of the crank type. The engine bed plates are separate castings, usually of cast steel, but sometimes of bronze, of I section, bolted at their ends to these guides, which are themselves carried by deeper longitudinals built into the hull of the ship, the space between them forming the crank-pits. They are stiffened by frames on each side and are connected by frames directly under, and bolted to, the bed plates. The guides are of cast iron of the slipper type with a water jacket behind the go-ahead face. They are bolted at their upper ends to a flange on the cylinder bottom, and at their lower ends to horizontal stays between the columns. The columns are usually of forged steel turned bright, and are stayed by horizontal stays passing through swellings in the columns, near their centers. Diagonal stays are generally also fitted. Exceptions to this type of framing are H. M. S. "Salmon" and "Snapper," in which the back columns are bronze, of bulb section and somewhat bow-shaped, the cast-iron guides being bolted to them by continuous vertical flanges. This section of column is stiffer, weight for weight, than the round column, but is much more expensive, and the same stiffness can be secured with round columns by the use of diagonal stays. The piston-rods and connecting-rods are drilled hollow to about half their external diameter, and the crossheads are in one piece with the piston-rods, the gudgeon pins being shrunk into the connecting-rod forks. The gudgeon pins are hollow and of specially hard steel. The engines are stayed to the bulkheads and to the ship's sides by stays consisting of tubes with palms welded on each end, running from gussets close under the deck, to lugs cast on the cylinders. The two sets of engines are similarly stayed to each other.

VALVE-GEAR.—Though the slot or locomotive link has been adopted in some of these vessels, the usual double-bar link is preferred, as it admits of adjustment in every wearing part, gives a truer motion, and is lighter for the same strength. The eccentric straps are of gun-metal or phosphor-bronze lined with white metal. They are ribbed between the bolts, usually by T or bulb-shaped ribs. Joy's assistant cylinder has been fitted in a few vessels of this class, and has reduced the wear on the valve gear considerably. This device consists of a piston connected to the valve spindle, working in a cylinder, to each end of which it admits steam in turn. By regulating the amount of steam admitted, it can be made to do the work of moving the valve in each direction, the valve gear merely controlling the length of travel. The all-round reversing gear still obtains, on account of its simplicity and compactness; the earliest destroyers were reversed by hand, but steam reversing gear was very soon introduced.

LUBRICATION.—The arrangements for oiling demand considerable attention in these rapidly moving engines. Centrifugal lubricators are fitted to the crank pins and often to the eccentrics; in addition, oil is led by the usual wick syphons from oil boxes placed at about the level of the cylinder bottoms. These boxes also supply oil for the guides, crosshead brasses and link motion. The main bearing oil boxes are situated lower down. Separate oil boxes are provided for the glands, as only mineral oil must be used. These engines, having hollow shafts, are well adapted for a system of forced lubrication, such as that used by Messrs. Belliss in their type of enclosed electric-light engine, in which the oil is forced by a pump through pipes passing through the shaft and crank webs to the crank pins, and thence to the crossheads and guide slippers. Water is led from the circulating pumps by pipes laid along each side of the engines, for playing on the eccentrics, bottom ends and main bearings, and for circulation through the water jackets in the guides and thrust blocks.

CONDENSERS.—The condensers are built of sheet-brass plates riveted together, and stiffened by angle rings. The tubes are of solid-drawn brass, ⅝-in. in diameter and about 18 L.S.G. in thickness; they are packed with the ordinary screwed ferrule and tape packing. Owing to their great length they require a central supporting plate. The circulating water flows through all the tubes together, making only one passage through the condenser. It is fed by scoops in the skin of the ship at the curve of the bilges. When the ship is at full speed the pump has little or no work to do but to keep pace with the water, as the speed of the ship is generally sufficient to force the water through the condenser. This is not, however, an advantage; in fact, it is certain that the scoop causes a resistance to the speed of the ship out of all proportion to the steam saved in the centrifugal pump, and the failure of some of these vessels to attain their contract speed at first has been traced to the form of scoop employed; some form of scoop is, however, a necessity, as the pump cannot suck in the water without one, and a scoop that is able to get the water into the suction pipe at all generally gives it sufficient velocity to carry it through the condenser. The ideal scoop should give the water just sufficient velocity to carry it to the circulating pump. The circulating pumps, of which there is one for each condenser, are of the centrifugal type, and are arranged so that the flow of water is as continuous as possible; they are driven by single-cylinder engines of about 3½-in. stroke, the full speed of which is about 300 revolutions per minute. A small air pump is driven off the crank shaft of each of these engines for clearing the condenser of water and to maintain the vacuum when the main engines are standing. It delivers to the feed tank and can also draw from the reserve tank to make up the feed. The fire and bilge pump is generally of the duplex type, and sucks from boiler-room and engine-room bilges or from the sea, and discharges overboard, or to a hose connection on deck when it is used as a fire pump. As a bilge pump it is assisted, when necessary, by bilge ejectors placed in the engine-room, in the stokeholds, and in the compartments forward and aft of the machinery space. These are placed on the skin of the ship close to the deck and merely consist of a nozzle emitting a jet of steam, which draws up the water from the bilges and discharges it overboard. They are useful in the event of the bilge pump getting choked, while they are not liable to get out of order, as they have no valves and the steam has a scouring effect.

A NEW PROCESS FOR FINISHING RAILS AT A LOW TEMPERATURE; EDGAR THOMSON STEEL WORKS, PITTSBURG, PA.

For a number of years the conviction has been gaining ground that the cause for the poorer wearing qualities of the railway rails which are now being rolled as compared with the rails rolled from twelve to fifteen years ago, is due to the practice of finishing the rolling at the high temperature which is necessary in the commercial production of rails of large section. In the older rails a comparatively low finishing temperature was possible owing to their smaller section and to the smaller proportion of metal in the head, together with the lower speed at which the old-time rail mills ran. As the size of the rail increased and the rate of production was pushed upward it became more difficult to secure this low finishing temperature, since owing to the large mass of metal in the head it was impracticable to cool it down to the requisite low temperature without reducing the temperature of the flange and web too low. To meet this difficulty Mr. Julian Kennedy, M. Am. Inst. M. E., of Pittsburg, Pa., and Mr. Thomas Morrison, Superintendent of the Edgar Thomson Steel Works, of the Carnegie Steel Co., have invented a process for finishing rails at a low temperature, and the necessary plant for its investigation and trial has been installed at the Edgar Thomson Steel Works. This plant and its operation are described by the inventors as follows:

After the steel ingots have been rolled in the blooming mill and sheared into blooms, they are conveyed to the Siemens heating furnaces in the rail mill and allowed to remain there until they are sufficiently hot to be rolled into rails. The rail mill, as it is now equipped, consists of three trains of rolls; the roughing train, where the bloom is passed forward and backward through five passes; it is then run to the intermediate, or "short" rolls, where it is given five passes in the same manner. The partially rolled rail, which has been elongated until it is now about 90 ft. in length, is then run to the special cooling table, which is but a few feet to the right of the main run, on which the rails are passed and which affords an interval of time of passage from the intermediate to the finishing rolls, during which time every individual rail can be brought to the same temperature, this temperature being that which has been found to produce the best results. It can be seen that on account of the greater amount of metal and heat contained in the head of the rail, it would, when cooling, cause the piece to be drawn into a curved shape, were it not for the precautions which have been taken, which, while being very simple, are still quite effective. The rail is laid on the cooling bed on its side with the head close up to the flange (or bottom) of the rail in front of it, so that the metal in the combination of two rails is about equally distributed, which allows the rails to cool gradually without causing them to become distorted. A great deal of the heat which leaves the head of the rail is absorbed in the flange of the rail adjoining it, thus keeping the temperature of the flange from being unduly lowered while the head is cooling. This is done without interfering with the rapidity or continuity of action of the mill, and it results in improving greatly the quality of the product.

After the rail leaves the intermediate rolls it is carried by a table of live rollers and delivered to the special cooling table by means of six "dogs" or "latches" atttached to ropes connected with drums on a common shaft, operated by means of a hydraulic cylinder and rack. Each of these ropes carries a second dog, the first set of dogs being adapted to drawing the rails onto the cooling table and to push over all the rails then on the table, which may amount to six or more, while the second set of dogs is arranged to draw one piece at a time onto the feed table of the finishing rolls, thus avoiding any danger of two pieces at a time being carried forward to the rolls.

After leaving the finishing rolls the usual processes are carried through, except that the rails do not need quite so much curving in the cambering rolls, on account of having less difference of temperature between head and flange than would be the case in the ordinary method of rolling. A great many experimental tests of various descriptions were made with this method of rolling, before it was decided to make such large and expensive changes at the Edgar Thomson Steel Works. Test pieces were taken from the heads of rails of different sections, ranging from 75 to 100 lbs. per yard—one rail being from a bloom rolled in the usual manner and another from the adjoining bloom in

the same ingot rolled at a lower temperature. These test pieces, after being highly polished and etched, were very critically examined, microscopically, and photographed. Photographs were taken from a section in the center of the head in each case and all magnified to 46 diameters. The rails from which the sections were photographed were, in the case of each weight, rolled from blooms made from the same ingot, the only change in the manufacture being in the variation in treatment at the rolls, as described, and it can be seen at a glance that, without exception, the steel rolled at the lower temperature is very much finer in structure, indicating a tougher and better wearing quality of steel. The tensile, drop and other tests also showed very much better results than in the same section of rails rolled in the regular way.

Figs. 1 and 2 are engravings from one of the sets of comparative photographs taken by Messrs.

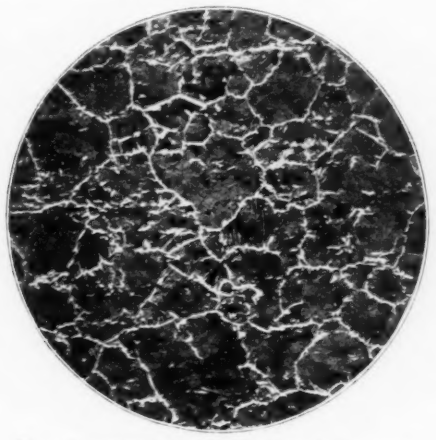


Fig. 1.—Rail Rolled by Usual Process.

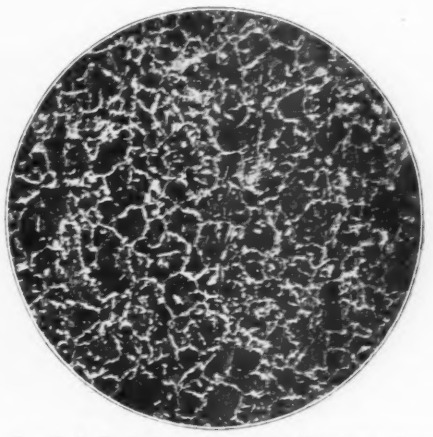


Fig. 2.—Rail Rolled by Kennedy-Morrison Process.

MICROPHOTOGRAPHIC SECTIONS FROM HEADS OF 85-LB. RAILS ROLLED BY USUAL PROCESS AND BY KENNEDY-MORRISON PROCESS.

Kennedy and Morrison, the rail in this instance being of 85-lb. section. Fig. 1 shows the section from the head of the rail rolled by the usual process and Fig. 2 shows the section from the head of the rail rolled by the special finishing process just described.

THE REPORT OF THE CHICAGO STREET RAILWAY COMMISSION.

The street railway situation in Chicago has been in an acute condition for a number of years past. Not long ago the people arose in their wrath and threatened extreme measures if the city council made an extension of street railway franchises for 50 years. There was a strong agitation for municipal ownership at the time, which has continued to exist.*

In view of all this agitation, and the fact that some important franchises expire in 1903, the board of aldermen passed a resolution on Dec. 18, 1899, providing for the appointment by the mayor of a committee of seven aldermen to "examine into the feasibility" of municipal ownership, the conditions under which new franchises should be granted and various other related subjects. On Jan. 3, 1900, Mr. Carter H. Harrison, Mayor, appointed such a committee, with Mr. Milton J. Foreman as chairman. Subsequently other resolutions were adopted by the aldermen and referred to the committee, including one relating to the advisability of constructing a subway for street railway traffic. In April, $4,000 was appropriated for the expenses of the commission, including the salary of a secretary. On June 12, 1900, Mr. Geo. C. Sikes entered upon his duties as secretary and on Dec. 17, 1900, the committee submitted its report, accompanied by a bill for introduction in the State legislature, entitled "An Act in Regard to Street Railways." This bill is to be followed by a second one, relating to subways. The main conclusions of the committee are embodied in the bill already drawn and the report is largely an elucidation of those principles. The report opens with the statement that "Chicago has more miles of street railway than any other city in the world." The two chief fixed principles under which street railways have been developed in Chicago have been local control and short term franchises. These the citizens of Chicago have been largely instrumental in forcing upon the State, after bitter struggles to prevent the adoption of a contrary policy.

To handle the street railway problems of Chicago, general legislation was necessary, so the commission has drawn a general street railway act, modified in some respects to suit rural sections. The principles guiding the commission in drafting the bill in question, although not necessarily all included in the bill, are summarized in its report as follows:

(1) UNIFICATION OF MANAGEMENT.—The street railway business should be recognized as a monopoly business and treated accordingly.

(2) PUBLIC CONTROL AND DURATION OF GRANTS.—These two subjects should be treated together because of the intimate relations they bear to each other. If street railways are to remain under private management some means must be devised for rendering public control more effective. The commission favors the reservation to the council of broad powers of control and for the exercise of the powers thus reserved it recommends the creation of a new standing committee on local transportation, modeled in the main after the Committee on Track Elevation. This committee should have regular quarters in the City Hall, which should be open during business hours for receiving complaints from citizens. The committee should have at its service such expert and clerical assistance as might be found necessary.

(3) MUNICIPAL OWNERSHIP.—Cities should possess the power, under proper restrictions and safeguards, to own and operate street railways. The city may not deem it expedient to exercise this power, but with such a power in reserve to be used in case of need, the city would be in a position to make much better terms with private corporations. The commission, while believing it wise and important to give the power to operate, would not look with favor upon the proposition to have the City of Chicago operate street railways in the immediate future. It has no notion that such a proposition would meet with the favor of the people of Chicago at this time. Problems of the future may safely be left to the decision of the future. The commission is of the opinion, however, that it would be wise for the city, at the earliest practicable time, to acquire ownership of the trackage and of whatever may form a part of the public street, without going to the extent of ownership and operation of rolling stock.

(4) REFERENDUM.—In so far as practicable, the people should be given a direct voice through the referendum in the settlement of the most important questions of street railway policy.

(5) PUBLICITY.—Street railway companies are entrusted by the public with the management of a public business. The affairs of such companies, therefore, should be open and known to the public to the same extent as if the business were managed by the public directly.

(6) CONTROL OF CAPITALIZATION.—The law should forbid overcapitalization.

(7) FRONTAGE LAW.—Frontage consents should be required only when it is first sought to lay down tracks upon a street. The right of abutting property owners to prevent a street from being used for street railway purposes, regardless of the public need for a proposed railway, should not be absolute and unqualified.

(8) LABOR POLICY.—The public has a right to demand uninterrupted street railway service. To that end, it has a right to insist that everything reasonably possible be done to prevent strikes and lockouts. Companies, in accepting grants, should be required to submit all labor disputes to arbitration.

(9) MOTIVE POWER.—The Chicago street railway field is profitable enough to warrant the use here of the most desirable form of motive power which experience has shown to be practical. The overhead trolley should not be permitted in the business district.

(10) SUBWAYS.—The commission is of the opinion, in so far as it is qualified to judge without the assistance of engineering experts, that Chicago should have a system of subways in the down-town district for the accommodation of street cars entering that district, thus making possible the removal of such cars from the surface of the streets within such subway district. The subject, however, is one calling for a careful and detailed investigation by engineers employed for that purpose by the city before any decisive steps are taken. Legislation should be secured at once permitting the construction and ownership of such subways either by the city or by a private corporation, which legislation should authorize the people themselves to say, through the referendum, which form of ownership they prefer, or whether they want subways at all.

(11) RATE OF FARE AND COMPENSATION.—These are matters requiring a more careful study than the commission has yet been able to make of them. The two should be considered together, for obviously the lowering of fares would reduce the possibilities in the way of compensation to be paid into the public treasury, and vice versa. The question of low fares vs. compensation and the question of the uniform fares as opposed to graded fares or the zone system of fares present themselves for consideration. The commission believes the question as to the amount of compensation for franchise grants should be left open until the terms of the grant otherwise are virtually decided upon.

(12) CO-ORDINATION OF SERVICE.—The commission is of the opinion that there should be more co-ordination between surface lines and steam and elevated roads.

(13) LEGAL QUESTIONS—THE 99-YEAR ACT.—When the companies now in control in Chicago receive any further grant of privilege from the city they should be required, as a condition of such grant, to renounce any claim of rights under the so-called Ninety-nine Year Act of 1865.

The bill drafted to embody most of the foregoing principles into the laws of Illinois may be summarized briefly, in its most important and interesting features, as follows:

No street railway shall be built without the consent of the local governing body and of the majority of the frontage of abutting property-owners on each mile of track, except that frontage consents will not be necessary "where an ordinance authorizing the location, construction or operation of a street railway" has been approved by a popular vote of the whole city. Franchises shall not extend over a longer period than 20 years and any franchise for more than five years may, on petition of 10% of the qualified voters of the city, be submitted to popular vote, in which event the franchise ordinance will be effective only in case it receives a majority of all the votes cast. Any franchise may be submitted to popular vote by the governing body, if it sees fit, without the petition just described.

Municipalities are authorized to insert a provision in street railway franchises to the effect that at the expiration of the same

> the whole or any part of the property of the grantee used for street railway purposes shall become the property of the city, without other compensation to the grantee than the privilege of operating street railways for the period of the grant.

At the expiration of any future street railway franchise grants, made by city councils, the city may buy property of the grantee at its

> then value (exclusive of any allowance for past or future profits of the undertaking, or any compensation for compulsory sale, or other consideration whatsoever) . . . . such value in case of difference to be determined by an engineer or other fit person, to be named on the petition of either party by any judge of an Appellate Court in the district where such property is located.

In case a city council refuses to renew a franchise, it must buy the property in question, if the company so desires, at a valuation to be made as just described.

On an affirmative vote of four-sevenths of the qualified voters voting on the proposition, any city may "own, construct, acquire, purchase, lease, maintain and operate street railways within its corporate limits."

Probably the most unique feature of the whole bill is set forth in the following language:

> Sec. 15. No bonds shall be issued by any city against the credit of the city for the acquisition or construction of street railways, but in payment for street railways acquired or constructed under authority granted by this act, any city may issue certificates of indebtedness or bonds, to be known as street railway certificates or bonds, which shall under no circumstances be or become an obligation or liability of the city, but which shall be limited in their payment solely to the street railway fund hereinafter provided for; such certificates or bonds may bear interest at a rate not exceeding 6% per annum, payable semi-annually, and shall only be issued at not less than par value in payment for the construction or acquisition of street railways, or for the extension, enlargement or improvement of the same, or to provide a working capital to meet expenses of

*See Engineering News, Oct. 20, 1898, for an abstract of a "Council Report on Street Railways in Chicago," in which the street railway situation is discussed at length.

maintenance or operation, in anticipation of revenues, or for the refunding of outstanding street railway bonds or certificates that may be issued under authority granted by this act.

The act provides in some detail for a street railway fund to meet all street railway obligations, and for including in the mortgage on such property a virtual franchise to bondholders who secure the property under foreclosure proceedings, after default by the city to meet its obligations as they fall due.

Where a city builds or in any way becomes the owner of a street railway system it may lease it to private parties for operation.

The bill requires full publicity of the financial affairs of street railway companies, through sworn statements on Dec. 31 of each year; full access to the books of account at any time by the State auditor; and a uniform system of accounts, to be prescribed by the State auditor. Another very important provision is the restriction of capitalization to 125% "of the cost and fair cash value of the tangible property belonging to the company and fully paid for by it." No stock or bonds may be issued except on the approval of the State auditor, treasurer and attorney-general, after a public hearing preceded by a public notice of at least 30 days.

ANNUAL MEETING OF THE AMERICAN ECONOMIC ASSOCIATION.

The thirteenth annual meeting of the association was held at Detroit, Mich., Dec. 27 to 29. Among the papers presented were a few of general interest and one or two which appeal directly to engineers.

THE TAXATION OF QUASI-PUBLIC CORPORATIONS.

This subject was formally presented by Messrs. F. C. Howe, of Cleveland, and F. N. Judson, of St. Louis. Mr. Howe called attention to the fact that the laws of the several states show great confusion and lack of uniformity in the taxation of public-service corporations. The recent tendency is to base the tax of such property, not on an inventory of the property itself, but on the market value of the stock and bonds, or the market value of the stock and the par value of the bonds. This is the plan followed in Connecticut and with some modifications in Massachusetts, New Jersey, Ohio, Indiana and Illinois. The plan has the merit of approval by the United States courts. New York taxes franchises.

Mr. Judson, in his paper on the same subject, outlined certain U. S. Court decisions relating to interstate railways, to the effect that "the value of a railroad in a state for taxation, means the part within the state of the value of the entire road" and the apportionment may be based on mileage and cars operated within the state. He said further:

The laws should provide a judicial remedy against inequality of assessments. The sources of state and municipal revenue should be separated, and the entire revenue from the assessment of the roadbed and rolling stock of railroads should be given to the state. A definite standard should be established of value by capitalizing the net revenues under the mileage rule, or the tax should be levied upon the net earnings.

In discussing the two papers, Prof. E. R. A. Seligman, of New York, said that corporate interests have such control over legislatures that proper legislation is frequently impracticable. He suggested that the power of taxing interstate railways should be vested in the national government. Mr. Jas. B. Dill, of New York, said that the public, sooner or later, pays the tax on corporations. Mr. Arthur J. Eddy, of Chicago, advanced the same view and urged that these corporations should not taxed, but that their rates should be closely regulated and kept down by public supervision.

COMPETITION.

The presidential address of Prof. R. T. Ely, of Madison, Wis., was devoted to "Competition: Its Nature, Its Permanency and its Beneficence." He said, in part:

Through the selective process of competition we have the survival of the fit. Society frequently creates the conditions. Civil service reform does not remove competition, but extends it. In all such social changes we have not the suppression, but rather a regulation of competition. Combinations of labor and of capital may expand freely, so long as these combinations mean merely association and co-operation. But when combination means monopoly, either competition must be restored or the ends of competition must be secured by social control; which may mean public ownership and management of industries.

There is a radical difference between the socialistic extension of governmental activity, which has in view the suppression of competition, and that conservative demand for an extension of governmental activity which has in view the maintenance of competition.

There are two somewhat antagonistic lines of desirable social evolution. One approaches—without hope of ever reaching—real equality of opportunities in economic competition. The other is found in the construction of great institutions which shut in and limit competition, but which nevertheless are the very foundations upon which our civilization rests, the depositories of race achievements. I have in mind the great economic-juridical institutions of private property, inheritance, and vested interests. The progressive approximation to equality in opportunities must not be permitted to go so far as to undermine these institutions. In the mutual adjustments of these two lines of evolution, we have given us one of the weightiest and most delicate tasks of the twentieth century.

Competition thus conceived is beneficent. It gives us a brave, strong race of men, and the brave and strong are merciful.

COMMERCIAL EDUCATION.

One session of the convention was devoted to commercial education. The first paper on this topic was read by Prof. E. J. James, of Chicago. Within the past few years ten or a dozen higher institutions have provided instruction in commercial education, including the Universities of Chicago, Pennsylvania, Ohio, Wisconsin, California and Vermont, Columbia and New York Universities and Dartmouth College. The universities have been forced to take up the work if they are to keep abreast of the times and if they are to prevent the establishment of numerous specialized schools, designed to teach this subject. It is claimed that 40% of the graduates of Yale go into business. Hosts of young men who do not enter college now would do so if more instruction in commercial education were provided. Thus far there are no well-developed courses in commercial education, but a beginning has been made and the subject may be expected, later on, to take its place with medicine, law and engineering. Business men are behind the movement and there is a demand from people who are willing to do more for their boys than can be afforded by the secondary schools, but who do not feel like sending them to the literary colleges. The American university should take the same attitude towards the training of business men as of professional men. Economics should be the fundamental study in such a course, as mathematics is to the engineer, and because it would give the same mental discipline. The course should tend to the technical, rather than the liberal studies.

Another paper on this general subject related to the science of accounts, and was read by Prof. Chas. W. Haskins, of New York University. He said that accounting is as truly a science as medicine, and is far more than bookkeeping, since it involves a knowledge of business and finance. He suggested courses of study for the training of public and private accountants.

The discussion on this paper was introduced by Prof. Frank H. Dixon, of Dartmouth College, who urged that so far as possible the commercial education should supplement rather than supplant liberal education, so as to train the man first and fit him for the profession afterwards. The college should be carried into business, rather than business into the college. The commercial training should begin not earlier than the senior year and continue one or two years later. The main objections to this plan are the time required and the fear that many students would not be attracted, but the work contemplated is for the training of leaders in business; quality rather than quantity should be the aim.

Prof. Wm. A. Scott, of Madison, Wis., while he agreed largely with the last speaker, was strongly inclined towards specialization. Of the freshmen in the course in commercial education at the University of Wisconsin at the present time, some 40% would not have come to college had there been no course of the sort and another 40% would have entered the enginering or law school instead. Professor Scott believed failure would result if there was merely a recombination of old courses of economics, history and the like with the new label of commercial education. Mr. M. N. Baker, of the editorial staff of this journal, said that the same general discussion as to specialization alone, or liberal education followed by specialization, had been gone over in the Society for the Promotion of Engineering Education. Many of the best men in that society, and many good engineers outside it, strongly favor the liberal education, followed by technical instruction. But there are also strong advocates of specialization, first, last and always. Of course, it must be recognized that for many it is technical education alone, or no education beyond the secondary schools. The ideal plan may be far in the future for the vast majority of students in commercial education, engineering and other technical branches, but the ideal should be kept in view and until it can be realized there should be as many as possible of the broader studies in connection with the technical courses. It is particularly desirable that the technical courses should give thorough training in English, so that the business man or the engineer, trained in either the commercial or engineering department of our universities, may be able to present a business or an engineering proposition in creditable and convincing language.

UNIFORM MUNICIPAL ACCOUNTS AND STATISTICS.

The final topic on the program was the report of the committee on uniform municipal accounts and statistics, the members of which were as follows: Professors H. B. Gardner, of Providence, R. I.; Chas. J. Bullock, of Williamstown, Mass.; E. Dana Durand, now of Washington, D. C.; Dr. E. W. Bemis, of Mt. Vernon, N. Y., and Mr. M. N. Baker, Chairman. The body of the report was devoted chiefly to a presentation of the scope of the present movement for uniform municipal accounting and the part which the American Economic Association could best take in the work. It was suggested that the general subjects of municipal finance might perhaps fall to the association, as a part of the scheme to assign topics to the several societies which have taken up the work. An alphabetical list of the subjects for which uniform municipal statistics are desirable was given as follows:

Baths,	Museums of art and science,
Bonded indebtedness,	Parks and playgrounds,
Bridges,	Paving,
Cemeteries,	Police,
Charities,	Printing offices,
Courts of justice,	Public buildings,
Crematories,	Real estate,
Docks and wharves,	Recreation,
Electric lighting,	River gagings,
Ferries,	Saloon and other licenses,
Finance (general),	Schools,
Fire protection,	Sewage,
Franchises,	Sidewalks,
Garbage disposal,	Special assessments,
Gas works,	Street cleaning,
Gymnasia,	Street lighting,
Hospitals,	Street railways,
Insurance,	Street watering,
Jails and prisons,	Taxation,
Latrines, public,	Telephones,
Markets and slaughter houses	Telegraph,
Messenger service,	Vital statistics,
Meteorological records,	Wash houses,
Municipal ownership,	Water-works.

The idea of the committee was that these subjects should be allotted among the various societies devoted to or interested in municipal affairs, for the formulation of uniform schedules for summaries of statistics, to be included in annual municipal reports, and that ultimately schemes for municipal accounting should be worked out for each of these topics, taking the most important ones first.

Already ten national and one state organization have appointed committees to co-operate in this movement for uniform municipal statistics. The names of these societies are as follows: American Economic Association; American Gas Light Association; American Public Health Association; American Society of Civil Engineers; American Society of Municipal Improvement; American Statistical Association; Central States Water-works Association; League of American Municipalities; National Electric Light Association; National Municipal League; New England Water-Works Association; New Jersey Sanitary Association.

The committee submitted the following summary of its conclusions:

1. That the interests of good municipal government, economics and public finance demand the collection and publication of state and national municipal statistics.
2. That such statistics, to be of service, should be based on uniform municipal accounting.
3. That, as a rule, American municipal accounting is in a most deplorable condition, being unsystematic, incomplete and misleading; with little correlation between the accounts of different departments of the same city, and the utmost diversity in the accounts of different cities, rendering comparison of the working of different departments and cities always difficult and often impossible.
4. That certain mooted questions of public policy, like municipal ownership, and day labor as compared with the contract system of executing public work, can never be thoroughly or properly studied until greater uniformity in municipal accounts and reports has been secured.
5. That co-operation between the various economic, sanitary, engineering and other technical societies interested in or devoted to municipal affairs, or some branch thereof, should be encouraged, to the end that uniform schemes for municipal accounts and reports, covering the various municipal undertakings and interests, whether in public or private hands, may be formulated and adopted.
6. That after the formulation and adoption of these schemes by such co-operative effort, it is desirable that steps should be taken to put them into use by the various municipalities of the country, either under the direction of state boards of municipal control, or special state commissions for different classes of undertakings and interests.
7. That a yearly comparative summary of the municipal statistics of the whole country, made and published by some branch of the national government, would place much valuable information within the reach of many investigators, to whom it would otherwise be unavailable, through lack of time to compile it, or through the impossibility of securing the many necessarily scattered reports.
8. That the summary of statistics for cities of 30,000 and upwards, compiled and published by the U. S. Department of Labor in 1899 and 1900, should be continued, pending improvements in municipal accounting, and that the present Census Office should make an exhibit showing the nature and general extent of municipal activities (a true census, or count) which would serve as a basis for more detailed inquiries after the organization of a permanent census or other statistical bureau, with a staff of experts in municipal engineering, sanitation, vital statistics and sociology, finance and economics generally.

There were three appendices to the report. The first was a condensation of the editorial in our issue of June 14, 1900, entitled "Uniform Accounting a Prerequisite to National Municipal Statistics." The second brought down to date the review of "Progress Towards Uniform Municipal Statistics in the United States," which appeared in our issue of July 5, 1900. The third appendix gave the names and addresses of the members of the various committees appointed to carry on the work under discussion.

The discussion on the paper was opened by Mr. Allen R. Foote, of Chicago, who reviewed his own efforts for ten years past, to secure uniform accounting, particularly as an essential to a study of the municipal ownership question. Mr. Foote presented resolutions, which were adopted, continuing the committee and giving it full authority to co-operate with other societies for the ends in view.

The election of officers resulted in the continuance in service of Prof. R. T. Ely, of the University of Wisconsin, as president, and Prof. Chas. Hull, of Cornell University, as secretary for the ensuing year. Washington was chosen, conditionally, as the place for the next convention, which will be held, as usual, at the Christmas holiday season.